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A REVIEW OF THE DEVELOPMENT IN THE NEW CENTRAL TEXAS OIL FIELDS DURING 1918.

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INTRODUCTION.

Nearly a year and a half ago on October 25, 1917, the J. H. McClesky well of the Texas and Pacific Coal Company near the town of Ranger was drilled in with an initial production of 1,200

barrels and opened up what is destined to be one of the world's greatest oil-producing areas. Previous to that time, central Texas had attracted but little attention as prospective oil territory. The Texas & Pacific Coal Company, while prospecting for coal with the diamond drill several years before, had encountered oil at a shallow depth in the Strawn formation of the Pennsylvanian and had subsequently developed the shallow Strawn pool in the extreme southwestern part of Palo Pinto County. Some of the wells at Strawn came in with initial productions of 75–100 barrels daily, but soon settled down to pumpers of 5–25 barrels daily capacity. The field proved rather spotted in character also, resulting in the drilling of many dry holes and so the experience in this region had a strong tendency, to discourage wildcatting in contiguous areas.

History.—The history of the present development in central Texas, however, did not actually begin with the drilling of the discovery well at Ranger. Some three years previously the Texas Company had geologists examining and studying structural conditions in the vicinity of Breckenridge, Stephens County. The result was the location and drilling of the original Parks well. This well found good production at the contact of the "Black Lime" and Smithwick shale of the Bend series of Mississippian age, but owing to the lack of storage and transportation facilities, it was pinched into 250 barrels daily, which production it is still maintaining after twenty months. The Parks well was thus the first well to indicate the possibilities of the Middle Bend as an oil horizon and it was the knowledge of this fact which gave W. K. Gordon, of the Texas & Pacific Coal Company, such confidence that he insisted on thoroughly prospecting this deep-lying formation before abandoning the work at Ranger.

The advent of a 1,200-barrel well is generally sufficient to cause a rush toward that vicinity and while a considerable number of oil men were attracted to Ranger, a great many also failed to regard the development seriously and adopted an attitude of watchful waiting. The writer can recall the time when acreage two to three miles from the McClesky well could be purchased

for $50 to $75 per acre, the same tracts a few months later commanding $800 to $1,500 per acre. The successful drilling of several additional wells, nearly all of smaller producing capacity than the McClesky, but extending over a mile or more of territory, was necessary to convince the oil fraternity in general that this new producing horizon in the Mississippian had wonderful possibilities. Shortly afterward, the bringing in of the famous Brewer well with an initial production of 2,200 barrels and the Jones well with an initial production of 4,500 barrels daily removed all remaining doubt about Ranger being a great oil field in the making.

The results of the drilling of the McClesky discovery well and its offset, the Davenport, immediately stimulated geological investigation which quickly assumed extensive proportions. Eastland, Stephens, Brown, Young, Comanche, Shackelford, Throckmorton, Coleman, San Saba, Mills and McCulloch Counties were carefully surveyed and, as a result, additional fields of great promise were found in Stephens County to the extreme north, in central Stephens County close to the towns of Breckenridge and Caddo, in southeastern Stephens County around the Veale well, in eastern Eastland County in the vicinity of the Allen ranch, and in the extreme northeastern part of Comanche County near the town of DeLeon. These fields have been designated as the Black brothers development, the Breckenridge, Caddo and Veale pools, the Allen pool, and the Duke or Comanche County field.

Areal Distribution.—If an irregular line is drawn to encompass the extreme outside producing wells at Ranger, this line at present would enclose an area of approximately 25 square miles. All of this 25 square miles may be termed probable producing area and will eventually be drilled. At least 75–80 per cent. of it should prove productive. The Whitson well, about 2 miles north of the town, and the Brashear No. 1 of McAlister et al., 5 miles south of town, define the present limits of the pool in a north-south direction. The W. L. McClesky well, 1½ miles slightly north of east of Ranger, and the Roper well, 3½ miles west of the town, prescribe the limits of present production in an

east-west direction. On January 1, 1919, about 50 producing wells were yielding 31,000 barrels of oil daily, making an average of nearly 600 barrels to the well; approximately 20 wells were shut down on top of the sand awaiting storage, 50 wells were drilling below 3,300 feet and 80 additional wells were rigging up or drilling.

Of the fields in Stephens County, the Breckenridge pool, 4½ miles south of the town of Breckenridge, has the most promising outlook at present. While this area may be said to be an outgrowth of the development around the original Parks well, previously mentioned, an intense drilling campaign was not commenced until some time after the Ranger discovery, so the real development was actually the result of that at Ranger. That portion of the Breckenridge pool which is being most intensively prospected at present covers an area of 4½ × 2½ miles in a N. 60 W. direction. Within this area are ten producing wells, the most important of which are the Lauderdale, Fincher No. 2, Davis and Brooks. The Lauderdale came in with an initial production of 1,000 barrels while the Fincher No. 2 of the Gulf Production Company made 2,200 barrels daily one week after being drilled in. There are now 44 locations or wells drilling in the vicinity of the Breckenridge pool. This development covers an area of 10 × 4 miles in a northwesterly-southeasterly direction and will undoubtedly define the limits of the field.

The Caddo field begins at the town of Caddo, 12 miles almost due east of Breckenridge, and extends from the town in a southwesterly direction. The most active development covers an area 3 × 2½ miles. The pool has 5 producing oil wells, 2 gas wells, and 2 dry holes. On January 1, 1919, there were 30 new locations or wells drilling. The Sandidge well of the Texas Company, which was drilled in several months previously, focused attention on this area. This well had an initial production of 1,000 barrels and on January first of this year, it was yielding 950 barrels daily.

The Veale pool centers around the Veale well of the Texas & Pacific Coal, Oil & Gas Company, 9 miles south of Caddo.

This well was drilled to 3,992 feet. A 20-foot gas sand was found at 3,960 feet which yielded several million cubic feet of gas and a little oil. The oil production has gradually increased until the well is yielding 500 barrels daily at the present time. The only other producing well in this pool on January first was the Sudderth, 2 miles west of the Veale. There were four producing gas wells, and 28 locations or wells drilling in this pool the first of this year. These tests cover an area of 50 square miles around the Veale well as a center.

The Black brothers well, 4½ miles east and 12 miles north of the town of Breckenridge, has probably opened a new pool in Stephens County. This well struck oil in the Smithwick shale and has been rated as a 200-barrel producer. It is being drilled to the top of the "Black Lime" where the big production in the Breckenridge district is obtained.

The Allen pool, 7 miles to the east of Ranger in Eastland County, has received less development work than any area of promise. This is probably due to the fact that two companies, the Sun and the Texas & Pacific Coal, Oil & Gas Company, control the biggest part of the acreage in this vicinity. The Allen well was drilled to the top of the Ranger sand where the tools were lost and never recovered. With the sand just penetrated at 3,037 feet, the well has been making 300 barrels daily, of which 50 per cent. is oil and 50 per cent. salt water. The offset to this well is now being drilled. Although the development of this field to date has failed to establish the presence of a pool beyond doubt, the future of the area looks very promising, since the territory is covered by one of the largest and best defined structures in the Pennsylvanian of Texas. This structure extends over into northwestern Erath County.

The Duke or Comanche County field is the latest area to be added to the producing column. The Duke or discovery well was drilled to the top of the pay sand in the Marble Falls or "Black Lime" on September 2, 1918. The drill had just penetrated the top of the sand when a strong flow of gas ignited and burned down the rig, leaving the tools in the hole from which

they have never been recovered. Without having ever been drilled in, the well has made 300 barrels daily. Recently the Knowles well, an offset to the Duke, reached the top of the pay sand and made 1,000 barrels a day. Later when this well was drilled in, it made 4,500 barrels daily. Shortly thereafter, the Joe Duke well, another offset to the original well of the field, reached the top of the sand and was reported making 1,000 barrels daily without having been drilled in.

Although these wells are the only producers in this area to date (January, 1919), their capacity indicates that a pool of considerable promise has been found. About 30 wells are now drilling. These wells extend over a 3-mile radius in all directions from the producers and will soon define the limits of the field. The first of these outside wells to reach the sand was the Davis located 3 miles north of the original Duke well in southeastern Eastland County. The Davis well had 65 feet of sand, but was dry, so this test partially limits the extension of the pool in a northerly direction.

Aside from the new fields which have just been briefly outlined, the discovery at Ranger has inaugurated the greatest period of wild-catting the State of Texas has ever known. From Bosque County in the eastern portion to the exterme Trans-Pecos in the west, at least 1,000 tests are being drilled in an attempt to open up additional new oil territory. Grayson, Denton, Tarrant, Bosque, Coryell, Bell, Milam, Lampasas, Hamilton, Erath, Hood, Parker, Wise, Montague, Jack, Young, Archer, Palo Pinto, Brown, Mills, San Saba, McCulloch, Menard, Concho, Coleman, Callahan, Shackelford, Throckmorton, Baylor, Hardeman, Haskell, Jones, Taylor, Runnels, Tom Green, Coke, Nolan, Fisher, Stonewall, Childress, Scurry, Wheeler, Crockett, Terrel and Pecos are some of the counties now being drilled as a result of the central Texas development and the indications for finding additional new fields are promising in some instances.

This constitutes in brief an outline of the history and development of the new Central Texas oil fields to date. The main purpose of this paper is to present some new and specific information

PLATE III.

FIG. A. Ranger, Texas, during the days of early development, July, 1918.

FIG. B. Brewer Hill, one of the richest spots in the Ranger Field. All the wells on this hill have averaged better than 1,800 bbls. daily initial production.

which a year of careful study and investigation has revealed concerning the stratigraphy of central Texas, the structural characteristics of the "Black" or Bend lime formation and its relation to surface flexures, the number and character of the producing horizons, the relation of certain tectonic influences to favorable structural conditions, and the future prospects of the fields already in the process of development as well as favorable and unfavorable territory for future investigation.

STRATIGRAPHY.

The various formations outcropping in central Texas or penetrated by the drill are shown in the following table, beginning with the youngest:

LOWER CRETACEOUS FORMATIONS.

These formations, principally the Trinity sands, Glen Rose limestone, Paluxy sand and Comanche Peak limestone, occur partly as outliers. They also form a high and prominent escarpment defining the eastern limit of the Pennsylvanian outcrops passing through western Mills, Hamilton, eastern Brown, western Comanche, western Erath, western Parker, eastern Wise and Montague Counties. A great unconformity separates the lowest member of the Lower Cretaceous from the underlying Permian or Pennsylvanian rocks, denoting a big hiatus. The Permian and Pennsylvanian formations dip normally west to N. 50 W., while the Cretaceous formations dip normally east to S. 50 E. The deposition of the Permian was followed by the withdrawal of the Permian sea and a general uplift of the strata as a result of the Appalachian revolution. This period was followed by one of great erosion wherein the Permian and Pennsylvanian formations were nearly reduced to a peneplain upon which the Lower Cretaceous strata were deposited. As a result of this stratigraphic relationship, favorable structure in the underlying Permian and Pennsylvanian rocks may very often have no reflection or indication in the overlying Cretaceous formations. The writer has examined thousands of square miles of

System.	Series.	Formation.	Description.	Thickness.
Cretaceous	Lower Cretaceous.	Trinity, Comanche Peak, etc.	Red to white sands, clays, chalky, marly limestone, etc.	Varying
—Unconformity—		—Unconformity—		
—Unconformity—	Permian	Double Mountain	Scarlet to gray clays, shales, sands and sandstones. Salt and gypsum.	1,800–2,000 feet
		Clear Fork	Deep red to gray sands, sandstones, clays, some limestone and gypsum.	1,500–1,800 feet
		Wichita-Albany	Deep red clays, shales and sands, largely. Albany beds are thin bedded limestones with alternating red to gray clays and shales.	1,000–1,500 feet
Carboniferous.	Pennsylvanian	Cisco	Red to brown sandstones, gray to red shales and clays, sandy limestones, coal.	800–1,000 feet
		Canyon	Thin to thick bedded, tabular to lenticular, gray limestones with alternating beds of gray to blue clays. Also some sands.	800–1,100 feet
		Local Unconformity		
		Strawn	Conglomerates, red sandstones and clays, blue to black shales, gray to blue limestones.	1,500–2,500 feet
	—Unconformity—		—Unconformity—	
	Mississippian	Smithwick Shale (Upper Bend)	Largely blue to black shales, often carboniferous, with some sand and little gray to black lime.	300–500 feet
		—Disconformity—	—Disconformity—	
		Marble Falls, Bend or "Black Lime"	Gray to black, compact, finely crystalline limestone, blue to black shales, sands.	100–900 feet
		Lower Bend	Black shale, often very bituminous, also some black lime.	75–125 feet
—Unconformity—	—Unconformity—		—Unconformity—	
Cambro-Ordovician		Ellenberger Limestone	Largely gray to white, massive, crystalline limestone.	100–1,000 feet

Cretaceous covered area wherein the strata have shown either a normal southeasterly dip or else lie almost flat; yet there is little doubt that these formations somewhere conceal favorable structure in the underlying Permian and Pennsylvanian which might contain oil in commercial quantity. The Lower Cretaceous in central Texas is not absolutely devoid of structure, however, and naturally the question arises—will such structures continue into the underlying Permian and Pennsylvanian? It is the opinion of the writer that in a good majority of the occurrences, these Cretaceous flexures will be found to be the result of post-Cretaceous folding along old Permian and Pennsylvanian flexures in which case the Cretaceous arches will be a reflection of structure in the underlying Permian and Pennsylvanian formations and likewise these latter flexures, in turn, might be indicative of structure in the Bend or Mississippian.

PERMIAN FORMATIONS.

The Double Mountain Formation of a maximum thickness of 2,000 feet is the youngest of the Permian series. In Oklahoma, its upper part has been called the Greer and the lower part the Quartermaster formation. It consists of deep to scarlet red clays, shales, sandstones, sands and sandy shales, thin beds of limestone and dolomite, bluish clays and shales, and thick beds of massive gypsum and rock salt. This formation outcrops in an area of some 20,000 square miles between Hall and Wilbarger Counties to the north, and Reagen and Tom Green Counties to the south.

The Clear Fork Formation has a maximum thickness of 1,800 feet. It forms part of the red beds and lithologically is very similar to the Double Mountain formation, excepting it does not contain so much gypsum and practically no salt. It outcrops in Wilbarger, Baylor, Throckmorton, Haskell, Jones and Shackelford Counties.

Wichita and Albany Formations.—The Wichita formation varies from 1,000 to 1,500 feet in thickness and consists of red clays, sometimes concretionary, red, blue, and grayish-white

sandstones, and occasional blue shales. It outcrops in Clay, Wichita, Baylor, Wilbarger, Archer, Young and Throckmorton Counties. Farther to the south and southwest, it is believed to grade imperceptibly into the Albany formation which consists predominatingly of thin-bedded, white to gray limestones with alternating marly, reddish to bluish clays. The thin-bedded limestones become more massive near the top of the formation which outcrops prominently in Mills, McCulloch, Concho, Runnels, Coleman, Young, Baylor, Throckmorton and Shackelford Counties. The Wichita-Albany beds constitute the lowest Permian formation and rest conformably upon the underlying Pennsylvanian formations, whereas in Southern Oklahoma, the Permian is unconformable with the underlying Pennsylvanian over considerable area.

THE PENNSYLVANIAN SERIES.

The Cisco Formation constitutes the upper division of the Pennsylvanian in central Texas and consists of 800 to 1,000 feet of red to blue clays or shales, red to gray sandstones, red, conglomeratic sandstones, and occasional thin beds of arenaceous limestone. North of Stephens County, the shales and sandstones are predominatingly red in color and the limestones are generally absent. South of the Stephens-Young County boundary, the gray shales and sandstones predominate in a number of localities and thin to massive beds of limestone are not uncommon, especially in Brown County. This formation contains some coal seams of a commercial value in Young County and its sands yield oil in prolific quantity from the deep wells at Electra and Burkburnett. The unusual amount of wildcatting in the red bed belt of the Texas Permian to the west of the Cisco outcrop is influenced largely by the strong probability of opening up another pool in the same horizon of the Cisco as that yielding the oil in north Texas, provided satisfactory structural conditions are obtained. The Cisco forms a broad stretch of outcrop extending in a general N. 30 E. direction from McCulloch County to the Red River through the counties of Brown and Coleman, Callahan, Shackelford, Stephens, Eastland, Young, Jack, Archer, Clay and Montague.

The Canyon Formation varies from 800 to 1,100 feet in thickness and consists largely of tabular, thin to heavy bedded, gray to white, crystalline limestone, highly fossiliferous, and alternating beds of gray to blue clay and shale. The limestone exposes a rough, gray, sandy surface on weathering. Occasionally red sandstone and conglomerates are observed as well as red clays. More sandstone and correspondingly less limestone is encountered to the north.

The Canyon is overlain conformably by the Cisco, but a pronounced unconformity separates it in some areas from the underlying Strawn beds. This unconformity[1] may be of a local nature only but is most marked in some areas, especially at Ranger. By reference to some of the well logs accompanying this paper, it may be observed that the thickness of the Canyon in the Jack Phillips well is 445 feet, in the J. H. McClesky well 580 feet, in the S. V. Davis well 825 feet, in the Jones well 974 feet, and in the Slayden No. 1, 980 feet. The surface elevations of these wells are as follows: Phillips 1,509, McClesky 1,515, Davis 1,445, Jones 1,563, Slayden 1,526. In the vicinity of Ranger, the Canyon has a general strike of N. 30 E. and an average dip of 40 feet per mile N. 60 W. The maximum dip of the Canyon here is only 60 feet per mile. A line bearing N. 30 E. through the J. H. McClesky well, will pass approximately 1 mile to the east of the Jones well. With an allowance of 100 feet for the difference in elevation and the dip of the formation between the Jones and McClesky wells, there is still a thickening of 294 feet in the Canyon in a mile which can only be reasonably accounted for on the basis of an unconformity. The Davis well lies 1½ miles slightly north of east of Ranger, the McClesky well 1 mile S. 30–40 W. of Ranger, and the Phillips well 2¼ miles S. 50 E. of the McClesky well or if a line bearing S. 30 W. representing the approximate strike of the Canyon beds were projected from the Davis well, this line would lie between the Phillips and Mc-

[1] Since this paper was written additional field work covering Brown County has demonstrated conclusively that the unconformity between the Canyon and Strawn occurs over a wide range of territory and is probably general in character.

Clesky wells, yet the Davis well has a lower elevation and 825 feet of Canyon as compared to 445 feet in the Phillips and 580 feet in the McCloskey well. These facts seem to establish the presence of an unconformity beyond much doubt.

The Canyon outcrops in McCulloch, Brown, Eastland, Stephens, Palo Pinto, Jack and Wise Counties.

Strawn Formation.—Early attention was attracted to the Strawn series on account of the finding of minable coal seams in it near the towns of Thurber and Strawn. This formation varies in thickness from 500 feet in southwestern Brown County to 2,500 feet in the vicinity of Strawn. The greatest thickness is 4,000 feet.

The Strawn consists largely of rusty, red sandstones, sands, shales, clays and conglomerates, blue to black shales, and some few beds of limestone. The greater portion of the formation is clay or shale. It has been subdivided into the upper, middle and lower Strawn, the middle beds being petroliferous and yielding shallow, productive oil wells near Strawn in Palo Pinto County, Ranger and Eastland in Eastland County, and Breckenridge and Caddo in Stephens County, also, at Lohm in McCulloch County. It outcrops conspicuously in Mills, San Saba, northwestern Lampasas, Brown, Eastland, Comanche, Erath, Palo Pinto, Parker and Jack Counties.

THE BEND SERIES.

The Smithwick Shale consists principally of black, carbonaceous shales with sand lentils. Blue shales and dark limestones are also found. The formation varies from 200 to 600 feet in thickness with an average thickness of 450 feet. A study of the Smithwick-Strawn contact reveals a marked unconformity separating these two formations. This is substantiated by the examination of well logs which show a variation in the thickness of the Smithwick of 200 to 300 feet in a mile in some areas. The sandstone lentils in this formation have yielded considerable gas and small quantities of oil. The Gray well in Coleman County, the first productive horizon in the Black brothers well of the Texas Company in northern Stephens County, the Chestnut well

in Palo Pinto County, and the gas in the Allen well in eastern Eastland County are all producing from the Smithwick.

The Smithwick shale has been classified by Sidney Paige[2] as part of the Bend formation of Mississippian age. There has been a tendency to view this correlation with doubt, some investigators contending that part of the Smithwick is of Pennsylvanian age. R. B. Dudley, of Mineral Wells, has recently found some fossils in the Smithwick, however, which are undoubtedly Mississippian. Ulrich has stated personally that he believes the Smithwick to be Upper Bend or Mississippian. C. L. Baker, formerly associated with the Bureau of Economic Geology of the State University of Texas, collected some fossils from an outcrop of Marble Falls limestone along the Colorado River near the town of Bend. These fossils were sent to Dr. Stuart Weller, who stated that they were new forms but unquestionably of Mississippian age. Thus the evidence seems rather conclusive that the Smithwick shale and the underlying formation, the Marble Falls limestone, are older than the Pennsylvanian. The accumulation of oil in great quantity at the contact of the underlying "Black Lime" or Marble Falls limestone with the basal Smithwick indicates the presence of a disconformity or possibly an unconformity.

The Smithwick shale outcrops in a narrow belt around the Llano Burnet uplift, more especially in San Saba County.

The Marble Falls Limestone or "Black Lime" Formation derives its name from a prominent outcrop of the same near the town of Marble Falls in Burnet County. It consists of black to gray limestone with alternating beds of black to blue shale. Some sandstones, more or less lenticular, and a little white lime are also found. Since attention has been so widely attracted to this formation since the discovery of oil within it at Ranger, it has been variously designated at the "Black Lime" or "Bend Lime," and from fossils found within the same, its age has been definitely established as Mississippian.

[2] Llano-Burnet Folio, No. 183, Geologic Atlas of the United States, by Sidney Paige.

The Marble Falls limestone varies from about 100 feet in thickness as shown by the log of the Cummings well of the Coline Oil Company near the town of Locker in San Saba County and by the log of the Abney well of Graham, Thomas and Ludlow 8 miles south of Brownwood to 970 feet in the Alvis well of the Oil State Petroleum Company, 2½ miles north of Grosvenor in Brown County. At Ranger, the thickness of this formation varies from 400 to 600 feet.

It is this formation which has recently yielded such prolific production in central Texas. It outcrops in a narrow belt near the southeastern part of the Burnet quadrangle, northeast of Bluffton, in the Riley Mountains in San Saba County, and in several places along the Upper San Saba River, the Colorado River and the Pedernales River.

Lower Bend Shale.—Near the bottom of the Bend series, immediately overlying the white to gray, crystalline Ellenberger limestone is a formation, 50–100 feet in thickness, composed largely of black, bituminous shale with some few strata of gray to black limestone. Udden[3] has named this specific unit of the Bend the lower Bend shale. This formation is often absent from the Bend series.

CAMBRO-ORDOVICIAN SERIES.

The Ellenberger Limestone Formation consists of a massive, white to gray, crystalline, dolomitic limestone, 100 to 1,000 feet in thickness. Thin beds of sand or sandstone may be found near the top of the formation. Near San Saba the Ellenberger limestone has been metamorphosed into marble, which has been used in the South for interior decoration.

The lower Bend shale directly overlies the Ellenberger limestone, a great unconformity separating these two formations. When the Ellenberger is penetrated by the drill in prospecting for oil, the test is generally abandoned if no commercially productive horizon has been encountered above. Graham, Ludlow and Thomas in their Abney No. 1, 8 miles south of Brown-

[3] "Review of the Geology of Texas," by J. A. Udden, C. L. Baker, and Emil Bose. Bulletin 44 of the University of Texas, page 42.

wood, drilled entirely through the Ellenberger nearly to the bottom of the Hickory sandstone, overlying the pre-Cambrian shists, without favorable result. A study of this most interesting and valuable log shows the following formations to have been penetrated.

0– 150 feet	Glen Rose limestone	Lower Cretaceous.
150– 250 feet	Trinity sands	
250–1,060 feet	Strawn formation	Pennsylvanian.
1,060–1,420 feet	Smithwick shale	Mississippian.
1,420–1,510 feet	Marble Falls or "Black Lime"	
1,510–2,100 feet	Ellenberger limestone	Cambro-Ordovisian.
2,100–2,600 feet	Wilberns and Cap Mountain formations, and Hickory sandstone	Cambrian.

STRUCTURAL GEOLOGY.

Surface Structure Type.—After eastern geologists, employed by the Texas & Pacific Coal Company, had made a careful examination of the Ranger field, prior to its discovery, they advised against expending the necessary funds to prospect the territory on two general principles, viz., the absence of what in their mind constituted favorable structure and the failure of past development to discover any sufficiently prolific and otherwise satisfactory producing horizon. The Strawn sands were of a spotted, erratic character, capable of yielding only small wells, while the Parks development in Stephens County was more or less of an unknown quantity.

A detailed survey at Ranger revealed very slight surface structure in the form of a combination nose and terrace with only eight feet of closure in the vicinity of the Walker well. Past experience had proved that such structures, themselves, possessed the most meager possibilities, sometimes yielding small pumping wells, but more often being barren altogether. If the eastern geologists entertained the possibility of such slight structure as at Ranger being indicative of larger and more pronounced structure in the Bend or Mississippian formations, and that in these

formations, oil sands of commercial value might be found, they evidently concluded the chances for such an unusual combination of favorable features to be so largely problematical as not to warrant serious consideration. Yet this is precisely what the discovery at Ranger revealed, namely that slight surface wrinkles, noses, terraces, etc., of small areal extent, which in themselves offered no commercial possibilities, might be indicative of very pronounced, extensive and favorable structural conditions in the Bend or Mississippian which in part was very bituminous in character and actually possessed prolific oil-bearing sands. Since then, actual development of such wrinkles, noses and terraces over several counties has yielded either oil or gas in commercial quantity from the Mississippian formations in 70 per cent. of the attempts, while many of the recorded failures were the direct result of the pinching or complete absence of the sand.

Relation between Surface and Sub-surface Structure.—It is important, therefore, to ascertain the relationship of these surface wrinkles to the underground structure, and in such an investigation, the value of accurate well logs is inestimable. Development which will give any accurate, detailed information of this character has proceeded sufficiently far in only one locality—Ranger,[4] where a careful study has revealed the following:

1. The sub-surface structure is many times greater in areal extent than the surface structure.

2. The sub-surface structure is much more pronounced than the surface structure.

3. The axis of the surface structure does not coincide with that of the sub-surface, the axis of the latter being a considerable distance to one side of the former.

4. As a result of the greater lateral extent of the sub-surface structure, the best part of such structure yielding the largest producers may be found underlying absolutely no surface structure whatsoever.

[4] The development in the Breckenridge field has now reached the stage where the relation of surface to sub-surface structure can be accurately ascertained.

5. The west and northwest side of the sub-surface structure yields the largest producing wells.

6. The thickness and porosity of the sand is of equal, if not greater, importance as structure. Where the sand pinches or thins or is cemented, dry holes will be drilled on structurally favorable locations.

7. The direction of dip of the sub-surface structure may be entirely opposite to the surface dip of the same area projected. In fact, the character of the surface dip may be no indication whatsoever of the character of the dip on the sub-surface structure.

8. The main axis of the sub-surface structure as a whole is in the general direction of the axis of the Bend arch which corresponds closely to the strike of the surface formations. Due to cross folding, one or several minor axes may develop along which larger producing wells may be found than in the vicinity of the main axis.

9. Localization of production is the direct result of cross folds superimposed upon the secondary folding parallel approximately to the axis of the main Bend arch. The axes of cross folding have a northwest-southeast trend and the complete resultant structure is very complicated due to the intensity of cross folding.

Details of Structural Conditions at Ranger.—While a sufficient number of wells extending over a wide area have been drilled to the top of the sand at Ranger to permit some considerable outline and definition of the structure from which fairly reliable and accurate conclusions may be drawn, development work has not proceeded to that degree to permit any considerable detailing of the structure. The contouring of the structure to date from nearly 100 well logs indicates that the longest and probably the main axis trends north-northeasterly, passing close to the Jones well and the H. Brashear well of McAlister et al. This axis is curving and locally may bear slightly northwest. From a contour map of the surface structure, the Walker No. 1 of the Texas & Pacific Coal, Oil & Gas Company was located on the small closure previously mentioned yet the Walker well is

actually 85 feet down the dip on the southeast or reverse side of the sub-surface structure in the Bend. The Jones No. 1 of the Humble Oil & Refining Company on the surface is situated well down the side of the nose and terrace in the vicinity of a west to southwest dip, yet the Jones is found to be practically on the highest point of the sub-surface structure close to the main axis. To the east of the Jones well, the sub-surface arch shows a strong southeasterly dip and to the west a heavy northwesterly dip—a marked divergence from surface conditions. Likewise in the vicinity of the Hagaman No. 1 of the Lone Star Gas Company east of Ranger, the surface shows a strong, normal northwest dip of 60 feet per mile while the sub-surface structure shows the dip to be changing from southeast to south to southwest and dipping at the rate of 200 feet per mile. From the Jones No. 1 to the Shook No. 1 to the southeast which later well defines the easterly extent of production in this vicinity, there is a southeasterly reverse dip of 160 feet in 8,000 feet or a drop of 5 feet in every hundred. The McClesky discovery well is located on the easterly or reverse side of the sub-surface structure and 100 feet down the dip from the axis which explains why subsequent wells farther west proved bigger producers. To date, the Brashear well of McAlister et al. is the highest point structurally on the anticline, being 25 feet higher than the Jones well. The contouring at present, while incomplete, indicates that these two wells are the centers of two domes along the main axis. The performance of the Brashear in yielding a large quantity of gas before producing much oil is now readily understandable. The same applies to the Duffer wells of the Texas Company just to the south of the Jones wells.

Whereas production on the east side of the structure has extended 160 feet down the dip where the sand condition has been regular before being limited by a series of dry holes, the production on the west side of the structure is found at least 235 feet down the dip in the case of the Butler No. 1 of the Texas & Pacific Coal, Oil & Gas Company and will probably extend 300 feet down the dip at least since the Roper well is rated as a good

producer and is located nearly three fourths of a mile west of the Butler.

The development of so many wells of large capacity three to four miles west and northwest of Ranger has led to the belief that the main trend of the Ranger anticline is in a northwesterly-southeasterly direction. There is practically no evidence to date to support this contention, which is far from logical. Considering the character of the orogenic forces which produced the Bend arch, it is but natural to expect that the minor or secondary folding which accompanied or was subsequent to this movement would occur along lines somewhat parallel to the axis of the main uplift which was in a direction approximately of N. 30 E. Subsequently secondary cross folding would result in specific localization of structural conditions exceptionally favorable for the accumulation of oil. Of course it is possible for the cross folding to have been of such magnitude as to make the axis of such folding the main and longer axis of the structure as at Caddo, La., but the projection and study of the sub-surface structure at Ranger up to the present time has revealed no evidence of this nature, every indication pointing to the longer or main axis extending in a general N. 20–40 E. direction with the axis of the cross folds nearly at right angles. The exceptionally strong dip to the west and northwest of the Jones No. 1 offers additional evidence to substantiate this view. There has been considerable speculation as to just how far to the west and southwest and down the dip production would extend at Ranger and although the Holcomb No. 1 of the Cosden Oil & Gas Company just east of Eastland and the Benedum & Trees well a short distance south of Eastland are practically dry holes in the Marble Falls limestone, this question has not been settled since these dry holes were the result mainly of the pinching or total absence of sands.

A number of small surface structures have been worked out in detail in the area north of the town of Eastland, suggesting the possibility of another large fold in the Bend with an axis approximately paralleling the axis of the Ranger anticline. This tentative view conforms with the element of probability more

than the attempt to explain any production which might be obtained in the future north of Eastland as due to an extension of the Ranger structure. The number of wells now drilling north of Eastland will shortly indicate if another large fold is there present. If such should be the case and a porous sand of average thickness is penetrated, yielding production, it would not be surprising to see production bridge over any synclinal basin between the folds, giving an area of continuous production from Ranger to a point several miles north of Eastland.

It is most significant that practically no salt water[5] has been encountered in the sands of the Marble Falls or "Black Lime." There is a considerable synclinal basin between the town of Ranger and the Davis, Vick and Phillips wells to the east. Several dry holes have been drilled in this syncline showing as much as 30 feet of sand without encountering any salt water. Salt water in quantity was found in the Allen well on the structure seven miles slightly south of east of Ranger, however. No satisfactory explanation has been advanced to date to account for this absence of salt water,[6] but it is most gratifying and insures a long life to the wells. This fact also places a much higher value on a well here than at El Dorado where the rapid encroachment of salt water has ruined some wells, greatly affected the capacity of others, and has caused the operators much anxiety and expense.

There are still large areas in the vicinity of Ranger which are favorably situated structurally, but which have received very little or no development to date. The territory due north of the town for several miles, the region north of the Hagerman wells of the Texas & Pacific Coal, Oil & Gas Company, the Lone Star Gas Company, and the Texas Company, the region east of the Davis, Vick and Phillips wells, and the area north, south, east and west of the H. Brashear well of McAlister et al. is included under this classification. The question of suitable production in the above areas depends directly on the presence of sands of suitable thickness and porosity.

[5] Lately salt water has been found in a few wells at Ranger.

[6] The general absence of salt water may be due to the lenticular nature of the sands which are found as irregular lenses in shale or lime and are non-water bearing and probably cut off any water from reaching the oil sands.

The Brashear well, structurally, is on about the highest part of the Ranger anticline. A study of the accompanying log of this well shows a complete absence of sands in the Marble Falls or "Black Lime" formation. Six to seven million cubic feet of gas was encountered at the contact of the Marble Falls limestone and the Smithwick shale. After this gas was partially exhausted, the well started to make oil and is now producing 300 barrels daily. The Texas & Pacific Brashear No. 1, one mile north, the Prairie Oil & Gas Company's J. T. Falls well, 1¼ miles slightly west of north, the Magnolia Petroleum Company's E. H. Webb No. 1, 2¼ miles north and the Ranger-Duncan Company's Minnie Sibley No. 1, 2¼ miles southeast of the McAlister Brashear are all dry holes for one reason—practically no sands. Thus a considerable area in this vicinity has been partially condemned, but sands of a lenticular nature generally develop suddenly and unexpectedly. It is the opinion of the writer that sands may be found to the southwest and some distance to the south of the Brashear well. This region is certainly worthy of several tests but only big companies with large reserve funds for prospecting are in a position to make the gamble.

The logs of the Vick, Berry and Phillips wells east of Ranger indicate an arching of the Marble Falls limestone in this vicinity, yet all these wells were practically dry for the same reason—absence of sands. Whether this arch is merely a nose or tongue of the main Ranger structure or the west flank of another fold of considerable magnitude is a question which can not be satisfactorily answered until more development work is done to the east of these wells. In the vicinity of Hagerman No. 1 of the Texas & Pacific Coal, Oil & Gas Company, the 1,690-foot contour and all contours below it change in strike from a N. 40 E. direction to an easterly direction and thence southwesterly to the S. V. Davis and W. L. McClesky wells of the Texas & Pacific Coal, Oil & Gas Company. There has not been sufficient development work around these wells to indicate whether the contours swing around them and assume a northeastward trend again or swing southward to form a long tongue or nose which

envelops the Vick, Phillips and Berry wells. This territory, however, is certainly worthy of more development.

It is the opinion of the writer based on a close study of the region that when development at Ranger has reached a stage where the sub-surface structure can be completely detailed, the structure will be found to consist of one large anticline with two or more closed domes and several prominent noses or fingers extending in all directions like the arms of an octopus as a result of the complicated cross folding of which there are strong indications already.

As a result of the evidence thus presented, the question naturally arises—how much dependence can be placed on surface structure in directing initial developments? The writer believes that the main value of surface structure lies in the fairly well established fact that its presence is generally indicative of structure in the Mississippian or Marble Falls limestone of much greater areal extent and more pronounced character. In making initial locations, there is no other recourse except the surface structure and the developments in all the new fields have proved that if initial wells are favorably located with respect to the surface structure, they will come within the producing area of the larger sub-surface structure although they will not necessarily be most favorably located with respect to such sub-surface structure. And since the surface structures are generally of very limited areal extent, it is only a question of a very short time, if the initial wells are productive, before intelligent development will have to be guided entirely by a close study of the sub-surface structure from the evidence presented by carefully kept well logs.

It must also be clearly recognized that some good, highly productive structure may be found in the Bend formations which have no favorable surface expression whatsoever. This is well illustrated by the S. V. Davis and W. L. McClesky wells of the Texas & Pacific Coal, Oil & Gas Company, 1½ miles east of Ranger. In the vicinity of these wells, the Pennsylvanian rocks at the surface show a normal, practically unbroken dip of 60 feet per mile to the northwest, whereas the sub-surface structure

in the Marble Falls limestone shows a southerly to southwesterly dip of 200 feet per mile. Prospecting for such blind structure, however, will demand considerable capital and will be successful in only a comparatively few instances. Such prospecting should be deferred until all surface flexures of a favorable nature have been found and investigated.

Likewise, as previously mentioned, owing to the marked unconformity between the Pennsylvanian, Permian and Cretaceous formations and the conditions governing the deposition of the same, areas covered by the Cretaceous rocks will generally show a normal easterly to southeasterly dip or local flattening, and in some few instances will conceal structure in the underlying rocks. Where definite structure is found in the Cretaceous formations, this structure has probably developed in the majority of instances along old lines of folding in the underlying rocks. Hence Cretaceous structure in central Texas in all probability is a surface reflection of underlying structure in the Permian or Pennsylvanian which in turn is generally indicative of structure in the Bend or Mississippian. Such Cretaceous flexures are worthy of a test. The writer knows of only two actually Cretaceous structures in central or northern Texas which have been drilled. The most prominent is located in northern Grayson County, north of Denison and has variously been designated as the Preston anticline, Munson dome, etc. Several wells have been drilled on this structure and have proved beyond question that the structure continues into the underlying Pennsylvanian. These wells have yielded a little gas and a show of oil but none of them were drilled sufficiently deep to test the possibilities of the structure fairly.

Surface Structure in Other Central Texas Fields.—Concerning the area around Breckenridge in Stephens County, several small and closely related wrinkles are observed in the vicinity of the present development. The structure around the Allen well in the extreme eastern part of Eastland County is the largest and best defined of any in central Texas. It extends over into northwestern Erath County and has 30 feet of closure. The struc-

ture around the Duke well is the poorest defined of all, but careful geological work established the presence of a reverse dip and the discovery well was located and drilled on this evidence. The Breckenridge, Allen and Duke developments were the direct result of careful geological investigation. Drilling in these areas has not progressed to the point where much detailed information is available concerning the sub-surface structure, but many of the same general conclusions drawn from a close study of the Ranger field will undoubtedly apply.

GENERAL TECTONIC RELATIONSHIPS.

In order to have a comprehensive knowledge of specific structural conditions and the causes of localization of structures as well as the necessary information to direct the prospecting for new structures in the most favorable territory, it is essential to understand the general structural conditions affecting the various formations of central Texas, the history of the orogenic movements which have established such conditions, and the tectonic relationships which have resulted. Cheney[7] and Hager[8] have called attention to the fact that the Bend or Mississippian formations of central Texas had been folded into a great arch or plunging anticline which extends over several counties, the axis of this arch having a general trend of about N. 20–30 E. and extending from the vicinity of Brady in the south to Graham in Young County in the north.

Stratigraphic History of North Central Texas.—A careful stratigraphic study of the central Texas area indicates that after the deposition of the lower and middle Bend formations, there followed a series of disturbances which resulted in at least a slight uplift and arching of the Middle and Lower Bend formations. The Smithwick shale was then deposited after which more intense orogenic movements occurred, resulting in the formation of what has been termed the Bend arch as shown in

[7] M. G. Cheney, *Oil Trade Journal*, April and May, 1918.

[8] Dorsey Hager, "Geology of the Oil Fields of North Central Texas," Bulletin 138, American Institute of Mining Engineers, June, 1918.

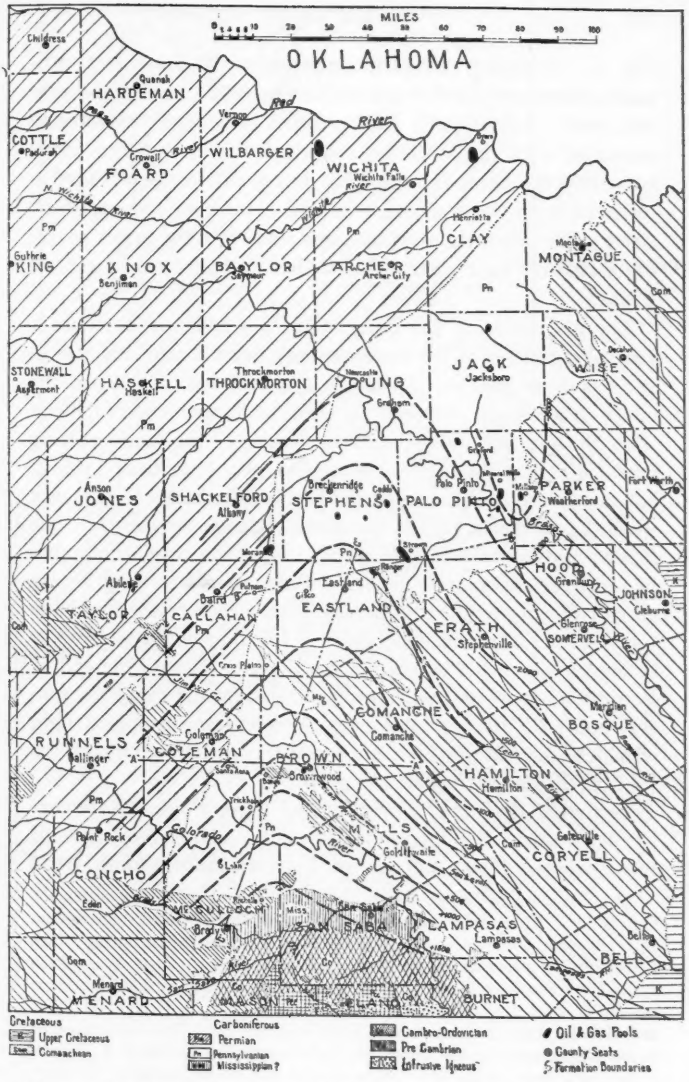

FIG. 5. The Bend Arch. After Hager, Bull. 138, June, 1918. Amer. Inst. Min. Eng.

Fig. 5. Secondary forces accompanying this movement, produced minor, parallel flexures whose axes had a northerly-southerly trend. Subsequently another series of orogenic movements associated with the Wichita-Arbuckle uplift in southern Oklahoma and the Llano-Burnet uplift in central Texas produced a series of cross folds whose axes had a more or less east-west trend. The intersections of the cross folds with the minor north-south flexures have yielded the oil-bearing structures of central Texas.

The magnitude of the Bend uplift was sufficient to cause a general regression of the sea, exposing a great area of the Smithwick shale to erosion. Thus the synclinal basins between the minor north-south flexures received additional accumulations while the anticlinal ridges had considerable of the shale covering removed. In some regions, peneplains may have been formed, but in general, the surface of the Smithwick shale was irregular when submergence again occurred. Upon this surface the Strawn beds were deposited. Well logs prove conclusively that in some regions at least the sea withdrew sufficiently to expose part of the Strawn to considerable erosion before the overlying Canyon formation was deposited.[9] After this hiatus, which may be local in character, deposition was continuous until the end of Permian time when gentler orogenic movements caused a general uplift of the area above sea level and superimposed light wrinkles and flexures in many instances in the vicinity of the folds in the underlying Mississippian.

Tectonic Relations of North Central Texas Pools.—Reference to Fig. 6 shows the importance of understanding these tectonic relationships. Thus an axis of a general north-south trend

[9] Detailed work in Brown County has revealed unconformities within the Canyon and Cisco formations indicating progressing folding throughout Pennsylvanian time. It was generally followed by quiescence during which the succeeding strata were deposited in normal condition. That several such cycles have occurred is revealed by field conditions which show limestone beds with normal northwest dip in the Canyon-Cisco underlain by highly arched lower beds showing reverse south and east dip. The importance of this condition was first brought to the writer's attention by Dr. S. L. Golpin.

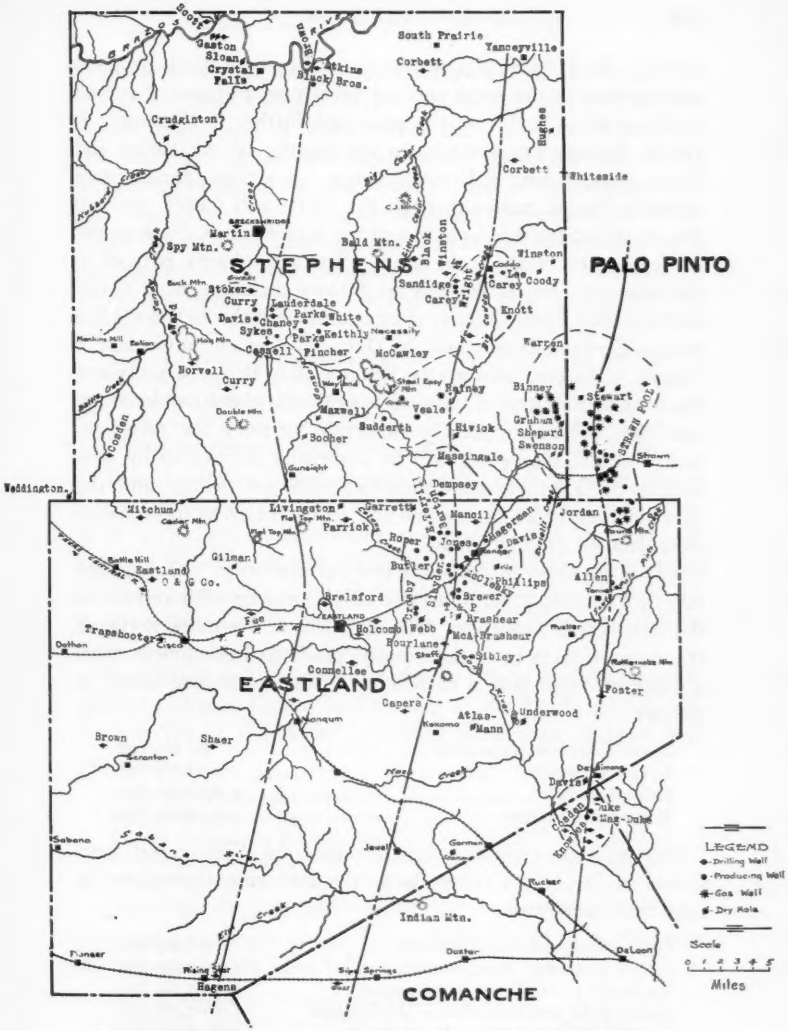

FIG. 6. Eastland, Stephens and Comanche counties, showing axial and tectonic relationships of the various pools. The above dashed outlines of various pools have no relation to surface structure but define approximate area of present development. They may be subsequently altered in detail with future development.

through the Breckenridge pool passes through the Black Brothers development to the north and the development around Eastland to the south. If this axis is projected further to the south, it passes through the structure in the vicinity of the Bailey and Bangs development in Brown County. A similar, parallel axis through Ranger passes through the Veale and Caddo pools to the north in Stephens County and the Sipe Springs development in Comanche County to the south. Still a third axis, parallel to the other two, passes through the Strawn shallow pool in southwestern Palo Pinto County, thence southward through the Allen pool in Eastland County and the Duke development in Comanche County. The area between the Bailey well in Brown County and the town of Eastland in the vicinity of the Eastland-Breckenridge axis thus becomes especially favorable territory for investigation; likewise new pools will be eventually discovered by projecting the axes of the Caddo-Veale-Ranger flexure and the Strawn-Allen-Duke flexure and subjecting the areas traversed to close detailed geologic study.

The Ellenberger Ridge.—Careful correlation of well logs has revealed another general feature of importance with respect to the Ellenberger limestone. The Ball No. 1, five miles north of the town of Myra in Cooke County, penetrated this limestone at a depth of 1,640 feet, a correlation of the formations being as follows:

Lower Cretaceous formations	0– 680 feet.
Strawn formation	680–1,185 feet.
Smithwick shale	1,185–1,640 feet.
Ellenberger limestone	1,640–2,675 feet.

Proceeding in a southwesterly direction, the Winston well near Caddo in Stephens County shows the following formations to have been penetrated:

Canyon formation—Pennsylvanian	0–1,215 feet.
Strawn formation—Pennsylvanian	1,215–2,795 feet.
Smithwick shale—Bend—Mississippian	2,795–3,260 feet.
Marble Falls limestone—Bend—Mississippian	3,260–3,480 feet.
Lower Bend shale—Bend—Mississippian	3,480–3,625 feet.
Ellenberger limestone—Cambro-Ordovician	3,625–3,733 feet.

In the vicinity of Ranger, the Phillips well of the Prairie Oil & Gas Co., the Crosby & Davis well, the Brashear well of McAlitser et al., the J. T. Falls well of the Prairie Oil & Gas Co., the Dean well of the Sammies Oil Co., the Webb well of the Magnolia Petroleum Co., the Holcomb well of the Cosden Oil & Gas Co., and two or three other wells have penetrated the Ellenberger formation. The logs of the Brashear and Phillips wells are presented in detail elsewhere in this paper. The following formations were found in the Dean well close to the town of Ranger:

Canyon formation—Pennsylvanian	0– 905 feet.
Strawn formation—Pennsylvanian	905–2,620 feet.
Smithwick shale—Bend—Mississippian	2,620–3,178 feet.
Marble Falls limestone—Bend—Mississippian	3,178–3,603 feet.
Ellenberger limestone—Cambro-Ordovician	3,603–3,709 feet.

Several wells have been drilled into the Ellenberger in Brown County among which are the Alvis No. 1 of the Oil State Petroleum Co., north of Grosvenor, the Bartles and Duminel well north of Brownwood, the Abney No. 1 of Graham, Thomas and Ludlow, eight miles south of Brownwood, and the Matlock No. 1, a few miles east of Brownwood. The logs of several of these wells have already been given.

Proceeding southwestward to the Trickham oil field in southeastern Coleman County and the log of the Producers Oil Co., Guthrie No. 1 shows the following formations to have been penetrated:

Cisco formation—Pennsylvanian	0– 162 feet.
Canyon formation—Pennsylvanian	162– 912 feet.
Strawn formation—Pennsylvanian	912–1,236 feet.
Smithwick shale—Bend—Mississippian	1,236–1,585 feet.
(Possibly a little Marble Falls in above.)	
Ellenberger limestone—Cambro-Ordovician	1,585–1,975 feet.

The log summary of the Dallas-Milburn well in northeastern McCulloch County is as follows:

Strawn formation—Pennsylvanian	0– 668 feet.
Smithwick shale—Bend—Mississippian	668– 947 feet.
Ellenebrger limestone—Cambro-Ordovician	947–2,266 feet.
Wilberns, Cap Mts., and Hickory sandstone formations—Cambrian	2,266–2,525 feet.

The Cawyer No. 1 of Burford and Brim situated about three miles slightly west of south of the Dallas-Milburn well in McCulloch County showed a similar condition, namely 260 feet of Smithwick shale lying directly upon the Ellenberger limestone with the Marble Falls lime completely missing. Finally the Cummings No. 1 of the Coline Oil Co., near the town of Locker in northern San Saba County, reported to be on an excellent structure, shows the following thickness of the various formations:

Strawn formation—Pennsylvanian	0– 394 feet.
Smithwick shale—Bend—Mississippian	394– 670 feet.
Marble Falls limestone—Bend—Mississippian	670– 760 feet.
Lower Bend shale—Mississippian	760– 805 feet.
Ellenberger limestone—Cambro-Ordovician	805–1,378 feet.

All of these wells which have penetrated the Ellenberger formation with the exception of the Brashear and Dean have been dry holes.[10] The well logs show the Ellenberger underlying the entire central Texas belt from Cooke County on the north to McCulloch and San Saba Counties on the south. A careful inspection of the logs reveals some very pertinent facts. The Smithwick shale in Eastland and Stephens counties has a thickness of 400 to 600 feet and the Marble Falls limestone likewise has a thickness of 400 to 500 feet. The well north of Myra in Cooke County shows 455 feet of Smithwick with the Marble Falls limestone entirely missing. The Matlock well in Brown County just east of Brownwood has 420 feet of Smithwick and only 180 feet of solid Marble Falls limestone which in turn rests directly upon the Ellenberger. It is important to note that this well had an eight foot gas sand in the Ellenberger formation at 2,345 which yielded several million cubic feet of gas daily and a sand showing oil at 2,353 to 2,365. This is the only test of record which has found any gas or oil in the Ellenberger limestone.

The Abney well eight miles south of Brownwood has 360 feet of Smithwick shale and only 90 feet of "Black Lime" or Marble Falls limestone. The Dallas-Milburn well in McCulloch County

[10] Production in the Brashear and Dean wells comes from the Marble Falls limestone and not from the Ellenberger.

has 279 feet of Smithwick shale, but no Marble Falls limestone is present. The Cawyer well has the Marble Falls limestone also completely eliminated. The Coline well, Cummings No. 1, northern San Saba County shows 276 feet of Smithwick shale and 135 feet of combined Marble Falls and Lower Bend formations. In this 135 feet there are no sands.

This data indicates conclusively that the Ellenberger limestone[11] forms a great irregular ridge which extends in a northeasterly direction from the point of outcrop in McCulloch and San Saba Counties to the Red River, roughly paralleling the axis of the Bend arch, but at some distance to the east of the same. The Smithwick shales seem to thin somewhat to the east, but more especially towards the south in the vicinity of this ridge while the Marble Falls limestone thins to the point of eliminating all the sands of the producing horizons below the top of the lime or pinches out against the ridge completely. For this reason, southeastern Brown County, southeastern Coleman County and the greater portion of McCulloch and San Saba Counties are decidedly unfavorable areas for prospecting. Shallow production from the Strawn and Smithwick formations is about all that might be expected from such territory.

Territorial Drilling Limits of Marble Falls Limestone.—The 3,000-foot contour on the top of the Marble Falls limestone passes through the southwestern corner of Jack County, the extreme northern part of Young County, diagonally through the center of Throckmorton County in a southwesterly direction, the southeastern part of Jones County, the northwestern corner of Taylor County and the southeastern corner of Nolan County. The average elevation in this region will approximate 1,500 feet, making the total depth from the surface to the top of the Marble Falls lime along the 3,000-foot contour about 4,500 feet. Assuming 4,800–5,000 feet as the limit of practical development, all counties west and northwest of this 3,000-foot contour must be eliminated in so far as reaching the producing horizons in the

[11] See conclusions of William Kennedy in "Recent Knowledge of Formations Below the Bend," *Southwestern Oil Jour.*, January 4, 1919, p. 1.

Marble Falls formation is concerned. This means that Baylor, western, northern and northwestern Throckmorton, northwestern Shackelford, nearly all of Jones, the northwestern part of Taylor, and practically all of Nolan, Fisher, Stonewall, King, Haskell and Knox Counties must depend on the horizons in the Cisco formation largely for any oil. It is the Cisco sands which are yielding the prolific production from the deep wells at Electra and Burkburnett. Where the Cisco was penetrated by the deep well at Spur in Dickens County to the west, the formation was found to be quite bituminous in character, but composed entirely of fine, crystalline, compact limestone, indicating that the Cisco sands may change to limestone in a westward direction. Under such conditions the Cisco offers but little encouragement for prospecting since there are no sands to act as reservoirs. It becomes important, therefore, to ascertain just where this change in the Cisco begins. More information will be had on this subject when some of the tests in these western counties are completed.

Hardeman and Foard Counties must depend also largely on the development of the Cisco horizons for oil although the Bend formations might be within reach of the drill in this region owing to the proximity of the Electra, Burkburnet, Petrolia uplift. In some of the above counties covered by the Permian red beds, it is also quite likely that oil and gas may be found in red bed lenses as a result of migration.

PRODUCING HORIZONS.

There are eight producing horizons in north central Texas[12] yielding oil in commercial quantity. They are:

1. Basal Canyon (top of Strawn?) sands—Pennsylvanian.
2. Middle Strawn sand—Pennsylvanian.
3. Smithwick shale—Mississippian.
4. Contact Smithwick shale with Marble Falls limestone—Mississippian.
5. Fincher sand of the Marble Falls limestone—Mississippian.
6. Gordon sand of the Marble Falls limestone—Mississippian.
7. Jones sand of the Marble Falls limestone—Mississippian.
8. Veale sand of the Marble Falls limestone—Mississippian.

[12] The Electra-Burkburnet-Petrolia fields are classified as the North Texas fields and are not included within the scope of this paper.

The only area to date producing from the basal Canyon sands is the shallow pool at Brownwood in Brown County. There is some doubt as to whether this horizon should be classed as basal Canyon. It is much more reasonable to assign this sand to the top of the Strawn series in this vicinity since the Strawn is composed essentially of sands and shales. Sandstones at the top of the Strawn beds outcropping just east of Brownwood are common. The Canyon formation is composed essentially of gray to blue, thin bedded to thick bedded, tabular to massive, lenticular limestones with alternating beds of blue to gray shale. Why include this sand as part of the formation? Lithologic characteristics, especially in the vicinity of Brownwood, do not justify it and the line of demarcation between the Strawn and the Canyon is largely defined by the change in lithologic character.

The middle Strawn possesses sands, generally lenticular, which have yielded small oil wells over a considerable range in central Texas. The first oil found in the region was from these sands in the vicinity of the town of Strawn in southwestern Palo Pinto County. Since the development at Ranger, several wells there have found production in this formation, some having been reported as yielding as high as 100 barrels initial production daily which is far above the average. Among such wells are the Crosby and Davis No. 1, the Holcomb No. 1 of the Cosden Oil & Gas Co., and the Warren No. 1 of the Lone Star Gas Co., the latter well being in southeastern Stephens County. The Lohm shallow field in McCulloch County is producing from the Strawn; also the gas wells several miles southwest of Bangs.

The Smithwick shale has yielded some oil and gas from lenticular sands found within the formation. The Gray wells in Coleman County, the Izod No. 1 of the Cosden Oil & Gas Co., near the Gray wells, and the first production from the Black Brothers well of the Texas Company in northern Stephens County found oil in this formation and the gas in the Allen well east of Ranger is coming from the same horizon.

Many big producing wells are obtaining their oil from the contact of the Smithwick shale and the Marble Falls limestone. This

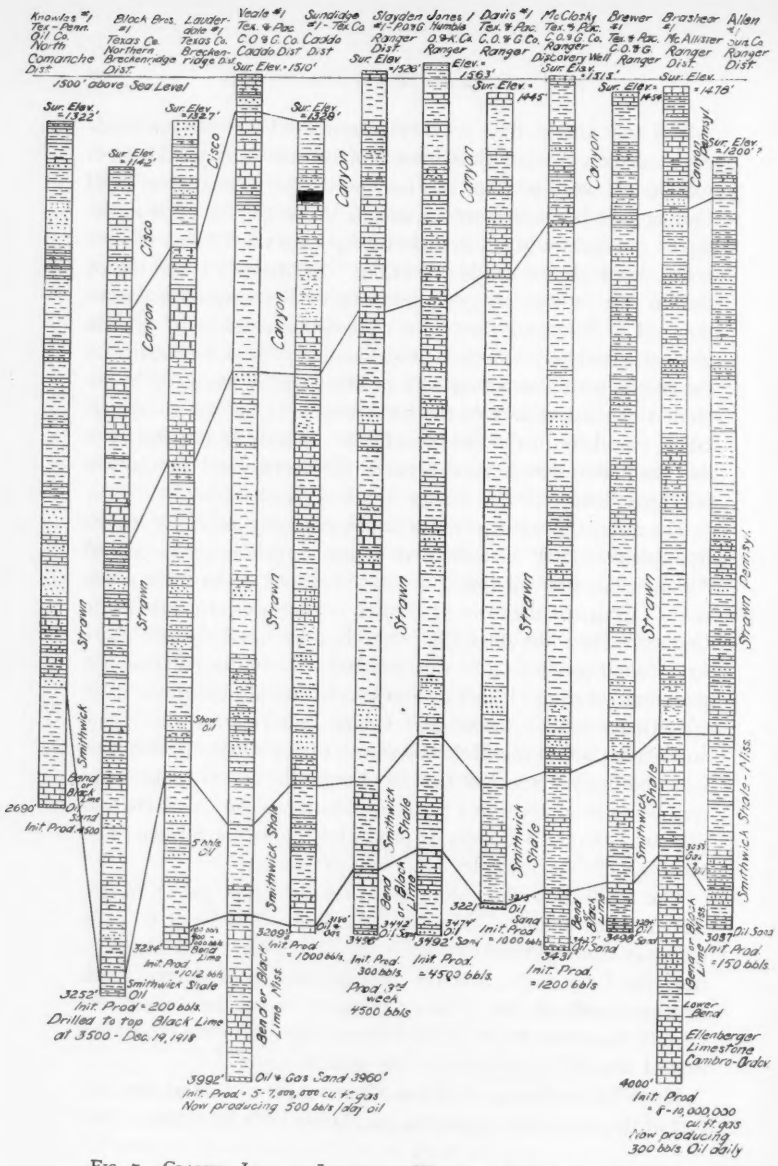
Knowles #1 Tex-Penn. Oil Co. North Comanche Dist.
Black Bros. #1 Texas Co. Northern Brecken-ridge Dist.
Lauder-dale #1 Texas Co. Brecken-ridge Dist.
Veale #1 Tex. & Pac. C.O.&G. Co. Caddo Dist.
Sundidge #1 - Tex. Co. Caddo Dist.
Slayden Jones #1 Tex. & Pac. C.O.&G. Co. Ranger Dist.
Davis #1 Humble O.&G. Co. Ranger
Davis #1 Tex. & Pac. C.O.&G. Co. Ranger
McClosky Tex. & Pac. C.O.&G. Co. Ranger
Brewer #1 Tex. & Pac. C.O.&G. Ranger
Brashear #1 McAllister Ranger Dist.
Allen #1 Dun Ca. Ranger Dist.
1500' above Sea Level
Sur. Elev. =1322'
Sur. Elev. =1327'
Sur. Elev. =1142'
Sur. Elev. =1510'
Sur. Elev. =1526'
Sur. Elev. = 1436'
Sur. Elev. = 1445'
Sur. Elev. = 1451.5'
Sur. Elev. = 1458'
Sur. Elev. = 1478'
Sur. Elev. =1200'?
Cisco
Canyon
Strawn
Smithwick Shale
Bend or Black Lime
Strawn Family
Show Oil
Oil & Gas
Oil Sand
Oil Sand Show
Bend or Black Lime Miss
Smithwick Shale - Miss
2690' Oil Sand Init. Prod. 4500
3252' Smithwick Shale Oil Init. Prod. = 200 bbls. Drilled To top Black Lime at 3500 - Dec. 14, 1918
3234' Init. Prod. = 1012 bbls
3209' Init. Prod. = 1000 bbls.
3440' Oil Sand Init. Prod. 300 bbls. Prod. 3rd week 4500 bbls
3474' Oil Sand Init. Prod. = 4580 bbls.
3492' Sand = 1000 bbls.
3431' Oil Sand Init. Prod. = 1200 bbls.
3087' Oil Sand Init. Prod. = 150 bbls.
3992' Oil & Gas Sand 3960' Init. Prod. = 5-7,000,000 cu. ft. gas Now producing 500 bbls/day oil
Lower Bend
Ellenberger Limestone Cambro-Ordov.
4000' Init. Prod = 8-10,000,000 cu. ft. gas Now producing 300 bbls. Oil daily

FIG. 7. GRAPHIC LOGS OF IMPORTANT WELLS IN NORTH CENTRAL TEXAS FIELDS. The terms "Marble Falls Limestone," "Black Lime" and "Bend Lime" are used synonomously. The first has precedence but the latter two are of more common usage. The fifth well should be spelt Sandige; the ninth McClesky. The depth of the tenth well should read 2498.

fact seems to be good evidence to support the contention that at least a disconformity exists between these two formations. The only wells yielding oil from this horizon at Ranger are the S. V. Davis with 1,200 barrels initial production, the W. L. McClesky with 1,200 barrels and the H. Brashear of McAlister et al. with 300 barrels daily production. Some of the most important wells in Stephens County, however, are getting their oil from this contact. Included in the list are the Lauderdale with 1,000 barrels, and the Sandidge with 1,000 barrels initial production.

The Fincher sand, so named by the writer because the largest well in Stephens County is producing from this horizon, is about 95 feet below the top of the Marble Falls limestone. The production is really coming from a sandy limestone. This seems to be true of many wells in this county, the well logs showing 100 to 200 feet of gray limestone with sandy spots occurring within the same at various horizons. The Davis well of the Gulf Production Company which had an initial production of 1,000 barrels is getting the oil from the Fincher sand 95 feet in this gray limestone.

The Gordon sand yielded the first production at Ranger and is the horizon from which nearly all of the wells there are now producing. It is found 130 to 225 feet below the top of the Marble Falls limestone. It is a distinct sand. The production in the Duke and Knowles wells in northern Comanche County is probably coming from this same horizon. The logs of these wells show the oil to be in a gray to black lime of sandy character. This black lime is 20 feet or so in thickness and is overlain by 110 to 160 feet of gray lime which has been also classed by the writer as a part of the Marble Falls limestone since no bed of limestone of such thickness has ever been found at the base of the Smithwick shale to date. Generally 100 to 200 feet of black Smithwick shale is always found just above the Marble Falls formation.

The Jones sand, so named by the writer because it seems to be an entirely different sand from the Gordon, was first found in the Jones well at Ranger which came in with an initial produc-

tion of 4,500 barrels daily. It is 325 feet below the top of the Marble Falls limestone.

The Veale sand, first found in the Veale well of the Texas & Pacific Coal, Oil & Gas Company south of Caddo in Stephens County, is 641 feet below the top of the Marble Falls limestone. Many operators have contended that this producing horizon was in the Ellenberger limestone and therefore opened up great possibilities for that formation. A close inspection of the Veale log, given elsewhere in this paper, will reveal the fallacy of this contention. The Veale sand is near the base of the Marble Falls limestone, but nevertheless a part of the same.

Thickness of Productive Sands.—There is much speculation as to the thickness of the producing sands. The only information to be had on this subject is by the logs of dry holes drilled through the sands. These logs show the Gordon sand to vary from six inches to 30 feet, with 18 to 20 feet a fair average and the Veale sand to be 20 feet in thickness. Whether the producing wells of large capacities will show a greater thickness of sand than given by the above figures is a question for speculation.

There is no doubt but what the sands in the Marble Falls limestone thicken and thin or pinch and often quite suddenly. For this reason, dry holes have been and will continue to be drilled on otherwise good locations from the structural standpoint. In this respect, the Ranger field is somewhat similar to the Caddo-Pine Island field of northern Louisiana where production, although intimately associated with structure, depends to a greater extent on the condition of the sand.

The number of producing horizons in the Bend series is of great economic importance when combined with the absence of salt water in some localities since it would seem to indicate that a long period of production is assured through the deepening of wells which have exhausted the sands near the top of the series. On the other hand, no two producing horizons have been encountered in any one well to date which suggests that the producing horizons are sand lenses at different depths into which the oil

has migrated from the shale, the oil in any specific area seeking the nearest reservoir or lens, leaving all other such lenses in that vicinity, above or below, in a barren condition. If future development shows this to be the case, the overlapping of lenses might result in additional production through the deepening of wells in some few instances.

CHARACTER OF PRODUCTION.

The oil at Ranger and other central Texas fields described in this paper is high grade, light gravity 34–40 Bé crude of an olive green color. An analysis shows the following percentage of ingredients for Ranger crude:

Ranger Crude—gravity 38.5°. Baume at 60° F.
Gasoline .....22.0 per cent., 59.9 gravity.
Naphthas ..... 3.8 per cent., 52.3 gravity.
Kerosene .....21.8 per cent., 43.9 gravity.
Residue (lubricating and fuel oil not separated)..52.0 per cent., 27.9 gravity.

The combination of quality and quantity of production obtained from the wells at Ranger, Breckenridge, the Duke vicinity, etc., has attracted the attention of operators throughout the country. The writer has tried to obtain voluminous statistics showing the date wells were drilled in, the initial production, and the present production in order to give some idea of how the production of the big wells was holding up. This information was only partly available at the time this paper was completed. Some gauge as to the exceptional manner in which the wells of large capacity are maintaining their production may be gained by reference to the record of the McClesky discovery well and its offset, the Davenport. These wells were drilled in with an initial production of approximately 1,200 barrels daily each and one year from date, each well was making better than 500 barrels daily. If other wells show similar tendencies, it is conservative to state that Ranger is likely to establish a new record for high average production and longevity per well. A short table showing the date, initial and present production of some of the most

important wells in the Ranger and Stephens County fields is given below.[13]

Well.	Owner.	Date Drilled in.	Initial Production.	Estimated Production End of Fourth Month.
J. H. McClosky, No. 1	Texas & Pacific Coal Co.	10/25/17	1,200 bbls.	850 bbls.
S. Davenport, No. 1	Texas & Pacific Coal Co.	About 12/22/17	1,200 bbls.	850 bbls.
F. Brewer, No. 1	Texas & Pacific Coal Co.	6/10/18	2,191 bbls.	1,250 bbls.
F. Brewer, No. 2	Texas & Pacific Coal Co.	8/14/18	3,100 bbls.	?
Merriman, No. 11	Texas & Pacific Coal Co.	8/14/18	1,500 bbls.	?
Merriman, No. 1	Wagner, et al	?	3,800 bbls.	?
I. Slayden, No. 1	Prairie Oil & Gas Co.	7/4/18	300 first week, then 4,500 daily	1,600 bbls.
Jones, No. 1	Humble Oil & Refining	7/8/18	4,500 bbls.	650 bbls.
Jones, No. 2	Humble Oil & Refining	About 9/28/18	1,800 bbls.	1,400 bbls.
Gholson, No. 1	Bartles, et al	?	900 bbls.	550 bbls.
Davis, S. V., No. 1	Texas & Pacific Coal Co.	7/29/18	1,000 bbls.	750 bbls.
Duncan, No. 1	Texas & Pacific Coal Co.	6/3/18	800 bbls.	350 bbls.
Lauderdale, No. 1	Texas Co.	About 3/25/18	1,200 bbls.	500 bbls.
Sandidge, No. 1	Texas Co.	April, 1918	1,000 bbls.	950 bbls.
Fincher, No. 2	Gulf Production Co.	9/18/18	At first 650 bbls., later 1,800	1,300 bbls.
Davis, No. 1	Gulf Production Co.	9/18/18	1,000 bbls.	600 bbls.

Note.—Last four wells are in Stephens County, rest in Ranger field.

SUMMARY.

1. The development in north central Texas following the Ranger discovery has resulted in the opening of six new additional fields of great promise, namely, Breckenridge, Caddo, Veale, Black Brothers, Allen and Duke.

2. The discovery of these new fields has inaugurated the greatest wildcat campaign in the history of Texas, extending from the Trinity River on the east into the Trans-Pecos country.

3. Geological investigation has demonstrated that slight sur-

[13] Additional production statistics, for all the wells of the Ranger pool, obtained just as this paper went to press, may be found in: *The Oil and Gas Journal,* Feb. 28, 1919, page 42.

face structure of small areal extent in the Pennsylvanian in the form of wrinkles, noses, terraces, etc., is generally indicative of structure in the Bend series of Mississippian age.

4. The sub-surface structure in the Bend formations is much more pronounced, better defined, and of much greater extent, areally, than the surface structure in the Pennsylvanian rocks.

5. All the new fields developed to date show some manifestation of surface structure. At least 70 per cent. of such surface structures in the Pennsylvanian formations which have been drilled to date have yielded oil or gas in commercial quantity.

6. Blind structure, or structure with commercial possibilities in the Bend that has no surface manifestations, occurs in a few instances.

7. The chief value of surface structure results from the fact that it serves as a reliable guide for initial developments. Wells favorably located with respect to the surface structure will generally be productive, but after the drilling of the first few wells, intelligent development must be directed from a close study of the sub-surface structure through the medium of well logs.

8. Favorable structural conditions for commercial accumulation of oil occur where cross folding has been superimposed upon extensive flexures resulting from the uplift which produced the Bend arch. The trend of the axis of the flexures is generally slightly northeast-southwest while the direction of the axes of the cross folds is nearly at right angles to the axes of the flexures.

9. A study of tectonic relationships shows the various fields to be situated along certain definite axes corresponding to the axes of the flexures resulting from the secondary folding associated with the Bend uplift. These axes are roughly parallel and are three in number, namely, the Eastland-Breckenridge-Black axis, the Caddo-Veale-Ranger axis, and the Strawn-Allen-Duke axis.

10. There are eight producing oil horizons in the central Texas formations. Six of these horizons belong to the Bend series and five of the latter six are in the "Black Lime" or Marble Falls limestone which is the source of the most prolific production.

11. The west and northwest side of the structures generally yield the largest and best wells. Production extends a considerably greater distance down the west and northwest side than the reverse or southeast side.

12. Although production is intimately associated with structure in the Bend, the condition of the sands is of equal importance. Where the sands pinch or are of a non-porous character, dry holes result even though favorably situated from a structural standpoint.

13. The Ellenberger limestone has formed a great ridge against which the prolific Marble Falls formation pinches out partially or completely in an easterly and southerly direction. These conditions have resulted in the practical elimination of several counties from the probable producing class since the Ellenberger has no value as an oil horizon.

14. The general absence of salt water and the unusual staying qualities of the wells in the Ranger field indicate a long life for this region with a high average production per well.

15. The developments of the next few months will undoubtedly result in the discovery of several new fields. The best territory for investigation preparatory to prospecting will be found by projecting the parallel axes through the various fields already under development and noting the area traversed by extending these axes.

16. A number of counties west of the Permian-Pennsylvanian contact have possibilities worthy of investigation. Many of these counties must depend largely on the Burkburnet sands of the Cisco formation for production, however, as the Marble Falls limestone, if present, will in general lie beyond a practical drilling depth. The presence of the Burkburnet sands in this western area is yet to be determined by the drill.

17. Cretaceous formations east of the outcrops of the Pennsylvanian completely obscure the structural features of the latter in many instances. Where structure in the Cretaceous is observed in counties bordering the eastern Pennsylvanian-Cretaceous contact, such structures should be tested.

REPRESENTATIVE LOGS OF VARIOUS CENTRAL TEXAS FIELDS.[14]

State, Texas. County, Eastland. District, Ranger. Well No. 1. Farm, J. Phillips. Well Owner, Prairie O. & G. Co. Sheet No. 1.

Formation.	From	To	Amt.	Formation.	From	To	Amt.
Mud	0	10	10	Blue slate	1815	1900	85
Quick sand	10	25	15	Gray lime	1900	1930	30
Gravel	25	35	10	Blue slate	1930	2000	70
Lime	35	60	25	Lime and sand	2000	2060	60
Quick sand	60	65	5	Blue slate	2060	2075	15
Slate	65	80	15	Lime	2075	2100	25
White lime	80	85	5	Blue slate	2100	2290	190
Blue slate	85	120	35	Blue lime	2290	2305	15
White lime	120	130	10	Blue slate	2305	2350	45
Blue slate	130	145	15	Sand	2350	2375	25
Gray lime	145	155	10	Blue slate	2375	2390	15
Blue slate	155	220	65	Sand	2390	2440	50
Gray lime	220	230	10	Gray lime	2440	2455	15
Blue slate	230	330	100	Blue slate	2455	2475	20
White lime	330	350	20	Sand	2475	2500	25
Blue slate	350	390	40	Slate	2500	2515	15
Lime	390	400	10	Lime	2515	2525	10
Blue slate	400	430	30	Sand	2525	2620	95
Lime	430	445	15	Slate	2620	2625	5
Blue slate	445	480	35	Lime and sand	2625	2660	35
Sand	480	575	95	Blue slate	2660	2700	40
Blue slate	575	600	25	Blue lime	2700	2725	25
Sand	600	660	60	Dark slate	2725	2860	135
Slate	660	765	105	Dark lime	2860	2895	35
Lime	765	800	35	Black slate	2895	2930	35
Blue slate	800	980	180	Lime	2930	2965	35
Gray lime	980	1000	20	Black slate	2965	3045	80
Blue slate	1000	1155	155	Lime	3045	3060	15
Sand—water	1155	1220	65	Black slate	3060	3200	140
Slate	1220	1235	15	Black lime	3200	3260	60
Slate	1235	1260	25	Gray lime	3260	3300	40
Slate	1260	1270	10	Black lime	3300	3380	80
Gray lime	1270	1275	5	Brown lime	3380	3390	10
Blue slate	1275	1445	170	Sand and lime	3390	3410	20
Lime	1445	1465	20	Black slate	3410	3445	35
Slate	1465	1480	15	White lime	3445	3470	25
Sand	1480	1510	30	Black lime	3470	3500	30
Blue slate	1510	1535	25	Gray lime	3500	3520	20
Sand	1535	1560	25	Black lime	3520	3560	40
Slate	1560	1575	15	Gray lime	3560	3650	90
Gray lime	1575	1580	5	Slate	3650	3660	10
Blue slate	1580	1600	20	Lime	3660	3760	100
Lime	1600	1610	10	Slate	3760	3765	5
Slate	1610	1625	15	Black lime	3765	3800	35
Lime and sand	1625	1675	50	Slate	3800	3850	50
Slate	1675	1680	5	Blue lime	3850	3875	25
Lime	1680	1695	15	Blue lime	3875	3895	20
Blue slate	1695	1705	10	Gray lime	3895	3910	15
Gray lime	1705	1720	15	Blue lime	3910	3960	50
Slate	1720	1725	5	White lime	3960	3990	30
Gray lime	1725	1760	35	Blue lime	3990	4000	10
Slate	1760	1790	30	White lime	4000	4005	5
Lime	1790	1815	25	Blue lime	4005	4010	5

Total Depth—4010.
Initial Production-Dry-Show of oil at 3390.

CORRELATION SUMMARY.

0–445—Canyon—Pennsylvanian.
445–2725—Strawn—Pennsylvanian.
2725–3200—Smithwick Shale—Upper Bend—Mississippian.
3200–3760—"Black or Bend lime"—Middle Bend—Mississippian.
3760–3850—Lower Bend—Mississippian.
3850–bottom—Ellenberger Limestone—Cambro-Ordovician.

[14] The following tables are copied from the regular form of well logs, with certain of the unused columns omitted for the sake of space.

State, Texas. County, Stephens. District, Caddo. Well No. 1. Farm, Sandidge. Well Owner, Texas Co. Sheet No. 1.

Formation.	From	To	Amt.	Formation.	From	To	Amt.
Yellow sand	0	4	4	Sand and water	1592	1617	25
Shale	4	11	7	Blue shale	1617	1648	31
Blue shale	11	90	79	Dark shale	1648	1690	42
Black shale	90	130	40	Sandy shale	1690	1745	55
Lime shell	130	150	20	Blue shale	1745	1850	105
Red Shale	150	152	2	Gritty lime	1850	1978	128
Lime	152	160	8	Blue shale	1978	1990	12
Blue shale	160	190	30	Sandy shale	1990	2100	110
Pink lime	190	210	20	Sand and water	2100	2135	35
Blue shale	210	220	10	Shale	2135	2150	15
Sand	220	250	30	Broken sand	2150	2158	8
Blue shale	250	280	30	Blue shale	2158	2210	52
Coal	280	320	40	Black shale	2210	2240	30
Blue shale	320	330	10	Sand	2240	2285	45
Lime	330	370	40	Blue shale	2285	2335	50
Blue shale	370	385	15	Sand—little oil and gas	2335	2345	10
White lime	385	450	65	Blue shale	2345	2390	45
Blue shale	450	470	20	Sand	2390	2393	3
Pink lime	470	485	15	Shale	2393	2410	17
Blue shale	485	595	110	Gas sand	2410	2496	86
Blue sandy shale	595	795	200	Water sand	2496	2510	14
Blue shale	795	810	15	Sand	2510	2516	6
Lime	810	860	50	Blue shale	2516	2530	14
Blue shale	860	870	10	Sand	2530	2541	11
Lime	870	880	10	Blue shale	2541	2550	9
Blue shale	880	910	30	White lime	2550	2600	50
Pink lime	910	930	20	Black shale	2600	2606	6
Blue shale	930	945	15	Sand	2606	2620	14
Gray lime	945	950	5	Blue shale	2620	2626	6
Blue shale	950	970	20	Black shale	2626	2680	54
Gray lime	970	980	10	Brown shale	2680	2740	60
Blue shale	980	995	15	Dry sand	2740	2750	10
Gray lime	995	1005	10	Black shale	2750	2774	24
Black sandy shale	1005	1055	50	Dry sand	2774	2790	16
Black shale	1055	1080	25	Black shale	2790	2840	50
Black sandy shale	1080	1105	25	Dry sand	2840	2855	15
Sand	1105	1120	15	White slate	2855	2870	15
Dark sandy snale	1120	1145	25	Dry sand	2870	2880	10
Black sandy shale	1145	1240	95	Blue shale	2880	2961	81
Blue shale	1240	1260	20	Brown shale	2961	3000	39
Gray lime	1260	1380	120	Black shale	3000	3060	60
Blue shale	1380	1385	5	Sandy lime	3060	3085	25
Gray lime	1385	1398	13	Black lime	3085	3114	29
Dark shale	1398	1408	10	Blue shale	3114	3119	5
Blue shale	1408	1452	44	Blue shale	3119	3180	61
Gray lime	1452	1582	130	Black lime—oil and gas	3180	3208	28
Blue shale	1582	1592	10				

Total depth—3209½ feet.
Depth of producing horizon below top of "Black lime"—90 feet.
Initial production—1000 bbls.

CORRELATION SUMMARY.

0–1005—Canyon formation—Pennsylvanian.
1005–2620—Strawn formation—Pennsylvanian.
2620–3180—Smithwick Shale—Upper Bend—Mississippian.
–3180—Top of "Black or Bend Lime"—Middle Bend—Mississippian.

State, Texas. County, Stephens. District, Breckenridge. Well No. 1. Farm, J. A. Lauderdale. Well Owner, Texas Co. Sheet No. 1.

Formation.	From	To	Amt.	Formation.	From	To	Amt.
Derrick floor to ground	0	3	3	Lime shell	174	182	8
Sand rock	3	76	73	Blue shale	182	234	52
Blue shale	76	85	9	Limestone	234	245	11
Lime shell	85	89	4	Blue shale	245	270	25
Red rock	89	100	11	Limestone	270	274	4
Blue shale	100	132	32	Sand—fresh water	274	283	9
Sand—little water	132	146	14	Blue shale	283	286	3
Blue shale	146	174	28	Dry sand	286	300	14

State, Texas. County, Stephens. District, Breckenridge. Well No. 1. Farm, J. A. Lauderdale. Well Owner, Texas Co. Sheet No. 2.

Formation.	From	To	Amt.	Formation.	From	To	Amt.
Limestone	300	307	7	Limestone	1891	1896	5
Blue shale	307	312	5	Blue shale	1896	1960	64
Light shale	312	348	36	Limestone	1960	1971	11
Water sand	348	359	11	Blue shale	1971	2005	34
Blue shale	359	362	3	Sandy shale	2005	2010	5
Light shale	362	367	5	Dry sand	2010	2020	10
Sandy shale	367	385	18	Sand—gas	2020	2026	6
Blue shale	385	400	15	Water sand	2026	2050	24
Light shale	400	415	15	Blue shale	2050	2054	4
Dark shale	415	506	91	Limestone	2054	2058	4
Black lime	506	513	7	Dry sand	2058	2068	10
Blue shale	513	519	6	Water sand	2068	2098	30
White limestone	519	532	13	Blue shale	2098	2128	30
Blue shale	532	539	7	Sandy shale	2128	2146	18
White limestone	539	582	43	Light blue shale	2146	2153	7
Blue shale	582	655	73	Limestone	2153	2156	3
Black shale	655	670	15	Blue shale	2156	2180	24
White limestone	670	946	276	Light blue shale	2180	2210	30
Broken lime	946	980	34	Blue shale	2210	2250	40
Dark shale	980	1135	155	Limestone	2250	2255	5
Blue shale	1135	1165	30	Light blue shale	2255	2270	15
Limestone	1165	1217	52	Blue shale	2270	2370	100
Shale—light	1217	1220	3	Shell	2370	2372	2
Limestone	1220	1236	16	Sand—showing oil	2372	2386	14
Gritty lime	1236	1240	4	Water sand	2386	2429	43
Gray shale	1240	1249	9	Black slate	2429	2435	6
White limestone	1249	1268	19	Sandy shale	2435	2439	4
Blue shale	1268	1278	10	Dry sand	2439	2443	4
White limestone	1278	1330	52	Limestone	2443	2445	2
Blue shale	1330	1346	16	Limestone	2445	2460	15
Limestone	1346	1363	17	Blue shale	2460	2583	123
Water sand	1363	1413	50	Dry sand	2583	2600	17
Blue shale	1413	1416	3	Blue sandy shale	2600	2630	30
White limestone	1416	1421	5	Blue shale	2630	2730	100
Blue shale	1421	1424	3	Lime stone	2730	2734	4
Sandy lime	1424	1433	9	Dry sand	2734	2738	4
Blue shale	1433	1436	3	Gas sand	2738	2740	2
Sandy shale	1436	1445	9	Dry sand	2740	2785	45
Blue shale	1445	1508	63	Blue shale	2785	2855	70
Limestone	1508	1529	21	Sand—5 bbls. of oil	2855	2861	6
Gray shale	1529	1580	51	Sand	2861	2869	8
Limestone	1580	1635	55	Blue shale	2869	2892	23
Red shale	1635	1644	9	Dry sand	2892	2920	28
Brown shale	1644	1657	13	Blue shale	2020	2095	75
Gray shale	1657	1671	14	Dry sand	2995	3012	17
Blue shale	1671	1685	14	Blue shale	3012	3188	176
Limestone	1685	1697	12	Gray lime	3188	3209	21
Blue shale	1697	1772	75	Gray lime—est. 160 bbls. oil daily	3209	3215	6
Gray shale	1772	1825	53	Gray lime—est. 400 bbls. oil daily	3215	3219	4
Red rock	1825	1836	11	Lime—dry	3219	3228	9
Water sand	1836	1838	2	Lime—gray—hard—1015 bbls oil daily est.	3228	3234	6
Sand	1838	1844	6	Black lime	3234	3284	50
Sandy shale	1844	1850	6				
Dry sand	1850	1886	36				
Blue shale	1886	1891	5				

Total Depth—3284 feet.
Depth of Oil Sand or Producing Horizon below "top of Black or Bend Lime"—00 feet.
Initial production reported—800–1000 bbls. oil daily.

CORRELATION SUMMARY.

0– 510—Cisco formation—Pennsylvanian.
510–1363—Canyon formation—Pennsylvanian.
1363–2600—Strawn formation—Pennsylvanian.
2600–3188—Smithwick Shale—Upper Bend—Mississippian.
–3188—Top of "Black or Bend Lime"—Middle Bend—Mississippian. Hole finished in the Black or Bend Lime formation.

State, Texas. County, Stephens. District, Breckenridge. Well No. 1. Farm, Black Bros. Well Owner, Texas Co. Sheet No. 1.

Formation.	From	To	Amt.	Formation.	From	To	Amt.
Surface soil	0	10	10	Sand	1710	1720	10
Yellow mud	10	30	20	Slate	1720	1745	25
Blue shale	30	60	30	Slate	1745	1770	25
Lime	60	70	10	Lime	1770	1795	25
Sand	70	92	22	Blue slate	1795	1865	70
Blue shale	92	204	112	Lime	1865	1870	5
Lime	204	230	26	Blue slate	1870	1875	5
Blue shale	230	285	55	Soapstone	1875	1885	10
Lime	285	292	7	Blue slate	1885	1896	11
Blue shale	292	302	10	Lime	1896	1911	15
Lime	302	306	4	Blue slate	1911	1990	79
Black shale	306	313	7	Lime	1990	1995	5
Lime	313	319	6	Sand	1995	2000	5
Blue shale	319	348	29	Blue shale	2000	2195	195
Lime	348	355	7	Lime	2195	2220	25
Blue shale	355	362	7	Slate	2220	2255	35
Water sand	362	410	48	Lime	2255	2290	35
Lime	410	438	28	Slate	2290	2320	30
Blue shale	438	540	102	Water sand	2320	2330	10
Black shale	540	552	12	Sand	2330	2340	10
Lime	552	621	69	Lime	2340	2355	15
Sand	621	627	6	Blue slate	2355	2385	30
Lime	627	640	13	Lime	2385	2395	10
Blue shale	640	740	100	Blue slate	2395	2415	20
Lime	740	746	6	Water sand	2415	2420	5
Water sand	746	766	20	Lime	2420	2440	20
Black shale	766	770	4	Blue slate	2440	2523	83
Blue shale	770	798	28	Lime	2523	2528	5
Sandy lime	798	811	13	Sandy lime	2528	2540	12
Blue shale	811	844	33	Hard lime	2540	2555	15
Lime	844	875	31	Sand	2555	2570	15
Blue shale	875	886	11	Blue shale	2570	2580	10
Lime	886	891	5	Sand	2580	2595	15
Blue shale	891	940	49	Brown shale	2595	2705	110
Lime	940	961	21	Slate	2705	2710	5
Blue shale	961	973	12	Sandy lime	2710	2725	15
Blue lime	973	994	21	Blue shale	2725	2765	40
White lime	994	1070	76	Lime	2765	2770	5
Blue shale	1070	1135	65	Brown shale	2770	2795	25
Lime	1135	1140	5	Lime	2795	2815	20
Blue shale	1140	1273	133	Blue shale	2815	2850	35
Lime	1273	1320	47	Slate	2850	2870	20
White shale	1320	1328	8	Lime	2870	2880	10
White lime	1328	1390	62	Blue slate	2880	2900	20
White slate	1390	1395	5	Lime	2900	2910	10
Blue lime	1395	1430	35	Slate	2910	2955	45
Blue shale	1430	1475	45	Lime	2955	2960	5
Lime	1475	1480	5	Blue shale	2960	2975	15
Sharp sand	1480	1490	10	Lime	2795	2980	5
White shale	1490	1505	15	Shale	2980	3005	25
Water sand	1505	1520	15	Sand	3005	3015	10
Blue slate	1520	1528	8	Slate	3015	3025	10
Sharp sand	1528	1531	3	Lime	3025	3030	5
Blue slate	1531	1535	4	Shale	3030	3045	15
Lime	1535	1540	5	Lime	3045	3050	5
Lime	1540	1545	5	Blue shale	3050	3095	45
Blue slate	1545	1560	15	Sandy lime—water	3095	3120	25
Lime	1560	1570	10	Blue shale	3120	3135	15
Blue shale	1570	1580	10	White shale	3135	3145	10
Water sand	1580	1625	45	White lime	3145	3175	30
Sand	1625	1660	35	Shale	3175	3184	9
Blue shale	1660	1670	10	White lime	3184	3200	16
Lime	1670	1685	15	Black shale	3200	3225	25
Sand	1685	1700	15	Black shale	3225	3240	15
Lime	1700	1710	10	Gray lime—oil	3240	3252	12

Total depth—3252 feet.
Oil sand—40 feet below top of Smithwick shale.
Initial production—About 200 bbls. daily.
Drilled deeper to approximately 3500 feet—Dec. 19, 1918.

CORRELATION SUMMARY.

0- 552 feet—Cisco formation—Pennsylvanian.
552–1480 feet—Canyon formation—Pennsylvanian.
1480–3200 feet—Strawn formation—Pennsylvanian.
3200–bottom—Smithwick Shale—Upper Bend—Mississippian. Top of "Black or Bend Lime" reported at 3500 feet.

State, Texas. County, Eastland. District, Ranger. Well No. 1. Farm, Allen.
Well Owner, Sun Company. Sheet No. 1.

Formation.	From	To	Amt.	Formation.	From	To	Amt.
Clay	0	10	10	Lime	1800	1820	20
Shell	10	12	2	Blue shale	1820	1875	55
Blue shale	12	70	58	Blue slate	1875	1885	10
Red rock	70	75	5	Blue shale	1885	1915	30
Lime	75	85	10	Black sand	1915	1930	15
Blue shale	85	90	5	Dark slate	1930	1975	45
Lime	90	95	5	Black lime	1975	1980	5
Blue shale	95	120	25	Black shale	1980	2015	35
Lime	120	130	10	Sand shells	2015	2035	20
White shale	130	160	30	Sandy shale	2035	2050	15
Blue shale	160	220	60	Black shale	2050	2075	25
White shale	220	240	20	Sandy shale	2075	2115	40
Blue shale	240	290	50	Sandy lime	2115	2150	35
White shale	290	300	10	Blue shale	2150	2180	30
Blue shale	300	322	22	Lime	2180	2185	5
Lime	322	325	3	Blue shale	2185	2190	5
Blue shale	325	345	20	White lime	2190	2200	10
White shale	345	357	12	Blue slate	2200	2210	10
Blue shale	357	380	23	Sandy shale	2210	2245	35
White shale	380	390	10	Lime	2245	2280	35
Blue shale	390	416	26	Black shale	2280	2305	25
White shale	416	430	14	Black slate	2305	2325	20
Blue shale	430	472	42	Black shale and slate	2325	2425	100
Sand—gas	472	498	26	Pink shale	2425	2455	30
Sandy shale	498	520	22	Black shale	2455	2460	5
Blue shale	520	600	80	Sandy shale	2460	2465	5
Dark shale	600	610	10	Sandy shale	2465	2500	35
Blue shale	610	638	28	Black shale	2500	2540	40
Lime	638	644	6	Sand—little gas	2540	2550	10
Blue shale	644	665	21	Black shale	2550	2660	110
Sandy shale—gas	665	680	15	Black slate or shale	2660	2695	35
Blue shale	680	704	24	Black shale	2695	2737	42
Lime	704	716	12	Black lime	2737	2757	20
Blue shale	716	770	54	Sand—gas	2757	2763	6
Water sand	770	798	28	Black shale	2763	2771	8
Gumbo	798	800	2	Sandy lime	2771	2791	20
Blue shale	800	822	22	Sandy shale	2791	2800	9
Water sand	822	845	23	Sandy lime	2800	2806	6
Blue shale	845	858	13	Sandy lime	2806	2812	6
Lime	858	864	6	Sand—good oil show	2812	2820	8
Blue shale	864	1007	143	Sandy lime	2820	2826	6
Blue shale	1007	1080	73	Blue slate	2826	2830	4
Sandy shale	1080	1285	205	Sandy lime	2830	2836	6
White slate	1285	1370	85	Sandy lime—gray	2836	2845	9
Lime shell	1370	1375	5	Gas sand—6,000,000 cu. ft.	2845	2854	9
White slate	1375	1412	37	Gas sand	2854	2858	4
Sandy shale	1412	1427	15	Sandy lime	2858	2865	7
Blue shale	1427	1457	30	Black slate	2865	2873	8
Lime shell	1457	1460	3	Sand	2873	2875	2
Sandy shale	1460	1480	20	Cap rock—8 million gas —show oil	2875	2879	4
Sand—gas	1480	1510	30	Sandy lime	2879	2890	11
Dark shale	1510	1520	10	Sandy lime	2890	2894	4
Sand	1520	1535	15	Black slate	2894	2896	2
Sand and shale	1535	1542	7	Gray sandy lime	2896	2921	25
Shell	1542	1550	8	Black sandy lime	2921	2941	20
Slate	1550	1560	10	Black sandy lime	2941	2948	7
Sand	1560	1576	16	Black slate	2948	2960	12
Shale	1576	1600	24	Black shale	2960	2990	30
Lime	1600	1605	5	Black sandy lime	2990	3000	10
Sandy shale	1605	1616	11	Black shale	3000	3014	14
Lime	1616	1645	29	Gray slate	3014	3022	8
Blue shale	1645	1661	16	Black shale and brown lime	3022	3032	10
Lime	1661	1664	3	Brown sandy lime—oil	3032	3037	5
Blue shale	1664	1700	36				
Sand	1700	1732	32				
Black shale	1732	1775	43				
Slate	1775	1800	25				

Total Depth—3037 feet.
Depth of Oil Sand below top of "Black or Bend Lime"—141.
Initial Production—150 bbls. oil daily with sand barely penetrated and tools in hole.

CORRELATION SUMMARY.

0– 160—Canyon formation—Pennsylvanian.
160–2280—Strawn formation—Pennsylvanian.
2280–2896—Smithwick Shale—Upper Bend—Mississippian.
–2896—Top of "Black or Bend Lime."

State, Texas. County, Stephens. District, Caddo. Well No. 1. Farm, Veale. Well Owner, T. & P. Coal, O. & G. Co. Sheet No. 1.

Formation.	From	To	Amt.	Formation.	From	To	Amt.
Soil	0	4	4	Blue shale	2425	2475	50
Lime	4	60	56	Gray lime	2475	2482	7
Blue shale	60	68	8	Blue shale	2482	2500	18
Gray lime	68	75	7	Lime	2500	2503	3
Water sand	75	85	10	Sand—dry	2503	2510	7
Blue shale	85	93	8	Gray lime	2510	2518	8
Water sand	93	128	35	Blue shale	2518	2527	9
Blue shale	128	157	29	Sand—dry	2527	2534	7
Gray lime	157	164	7	Shale and lime	2534	2590	56
Blue shale	164	174	10	Blue shale	2590	2635	45
Gray lime	174	249	75	Lime	2635	2642	7
Blue shale	249	280	31	Sand—dry	2642	2665	23
Lime	280	310	30	Blue shale	2665	2675	10
Blue shale	310	355	45	Gray lime	2675	2685	10
Lime	355	390	35	Blue shale	2685	2708	23
Blue shale	390	396	6	Lime and sand	2708	2741	33
Gray lime	396	455	59	Water sand	2741	2756	15
Blue shale	455	467	12	Blue shale	2756	2776	20
Gray lime	467	487	20	Dry sand	2776	2845	69
Water sand	487	502	15	Blue shale	2845	2857	12
Blue shale	502	522	20	Lime, sand and shale	2857	2960	103
Dry sand	522	535	13	Blue shale	2960	3005	45
Gray lime	535	550	15	Black shale	3005	3205	200
Blue shale	550	790	240	Black lime	3205	3209	4
Pink shale	790	795	5	Black shale	3209	3215	6
Blue shale	795	1248	453	Black lime	3215	3218	3
Dry sand	1248	1298	50	Black shale	3218	3250	32
Blue shale	1298	1360	62	Black lime	3250	3254	4
Pink shale	1360	1367	7	Black shale	3254	3319	65
Gray lime	1367	1372	5	Black lime	3319	3349	30
Pink shale	1372	1384	12	Black shale	3349	3382	33
Blue shale	1384	1540	156	Black lime	3382	3398	16
Gray lime	1540	1546	6	Black shale	3398	3408	10
Sand—dry	1546	1553	7	Black lime	3408	3416	8
Blue shale	1553	1765	212	Black shale	3416	3433	17
Gray lime	1765	1771	6	Blue shale	3433	3538	105
Blue shale	1771	2082	311	White lime	3538	3578	40
Gray lime	2082	2120	38	Black lime and shale	3578	3717	139
Broken sand—gas	2120	2128	8	Black lime	3717	3877	160
Shale	2128	2133	5	Black shale	3877	3960	83
Sand—dry	2133	2180	47	Gas sand	3960	3980	20
Shale—blue	2180	2415	235	Lime and shale	3980	3992	12
Gray lime	2415	2425	10				

Total Depth—3992 feet.
Depth of Oil Sand below top of "Black or Bend Lime"—641.
Initial Production—5–7,000,000 cu. ft. gas. After several months started to flow oil. Now producing 500 bbls. oil daily.

CORRELATION SUMMARY.

0– 157—Cisco formation—Pennsylvanian.
157–1248—Canyon formation—Pennsylvanian.
1248–2960—Strawn formation—Pennsylvanian.
2960–3319—Smithwick Shale—Upper Bend—Mississippian.
–3319—Top of Bend or Black Lime.

State, Texas. County, Eastland. District, Ranger. Well No. 1. Farm, H. Brashear. Well Owner, McAlister et al. Sheet No. 1.

Formation.	From	To	Amt.	Formation.	From	To	Amt.
Soil	0	13	13	Lime	135	139	4
Lime	13	25	12	Blue shale	139	177	38
Rock	25	39	14	Lime	177	181	4
Blue shale	39	43	4	Blue shale	181	190	9
Lime	43	47	4	Dry sand	190	200	10
Blue shale	47	67	20	Blue shale	200	202	2
Lime	67	74	7	Lime	202	292	90
Blue shale	74	96	22	Blue shale	292	300	8
Lime	96	100	4	Lime	300	306	6
Blue shale	100	106	6	Blue shale	306	322	16
Lime and sand	106	127	21	Lime	322	343	21
Blue shale	127	135	8	Blue shale	343	348	5

State, Texas. County, Eastland. District, Ranger. Well No. 1. Farm, H. Brashear. Well Owner, McAlister et al. Sheet No. 2.

Formation.	From	To	Amt.
Lime	348	359	11
Blue shale	359	390	31
Sandy lime—water	390	395	5
Shale	395	425	30
Sand	425	437	12
Shale	437	445	8
Sand—shelly	445	485	40
Shale	485	492	7
Lime	492	495	3
Sand	495	584	89
Blue shale	584	590	6
Red mud	590	598	8
Shale	598	612	14
Lime	612	614	2
Blue shale	614	640	26
White shale	640	680	40
Blue shale	680	708	28
Lime	708	712	4
Blue shale	712	757	45
Sand	757	760	3
Blue shale	760	775	15
Water sand	775	793	18
Blue shale	793	846	53
Lime	846	850	4
Sand	850	857	7
Shale	857	870	13
Dry sand	870	876	6
Blue shale	876	971	95
Lime	971	979	8
Blue shale	979	1005	26
Blue lime	1005	1020	15
Shale	1020	1095	75
Lime and sand	1095	1100	5
White shale	1100	1106	6
Sand	1106	1114	8
Shale	1114	1120	6
Sand	1120	1132	12
Shale	1132	1141	9
Lime	1141	1146	5
Blue shale	1146	1390	244
Lime	1390	1393	3
Blue shale	1393	1413	20
Lime and gas sand	1413	1418	5
Water sand	1418	1440	22
White shale	1440	1445	5
Lime	1445	1459	14
Shale	1459	1465	6
Blue shale	1465	1469	4
Lime	1469	1487	18
Dry sand	1487	1495	8
Shale	1495	1512	17
Lime	1512	1517	5
White shale	1517	1557	40
Lime	1557	1570	13
Blue shale	1570	1576	6
Sandy lime	1576	1583	7
Shale	1583	1606	23
Water sand	1606	1650	44
Shale	1650	1651	1
Lime	1651	1665	14
White shale	1665	1690	25
Lime	1690	1692	2
Blue shale	1692	1800	108
Black shale	1800	1820	20
White shale	1820	1927	107
Lime	1927	1930	3
Blue shale	1930	2200	360
Lime	2290	2300	10
Shale	2300	2302	2
Dry sand	2302	2307	5
Shale	2307	2340	33
Dry sand	2340	2360	20
Shale	2360	2375	15
Sand	2375	2381	6
Shale	2381	2432	51
Lime	2432	2435	3
Shale	2435	2445	10
Broken dry sand	2445	2515	70
Blue shale	2515	2555	40
Black shale	2555	2620	65
Lime	2620	2625	5
Blue lime	2625	2710	85
Black lime	2710	2716	6
Black shale	2716	2740	24
Blue lime	2740	2783	43
Black shale	2783	2870	87
Black lime	2870	2875	5
Shale and shells	2875	3035	160
Black lime—gas	3035	3075	40
Black shale	3075	3078	3
Black lime—little gas	3078	3084	6
Black shale	3084	3087	3
Black lime	3087	3110	23
Black shale	3110	3146	36
Lime	3146	3179	33
Gray lime	3179	3199	20
Dark gray lime	3199	3205	6
Black lime and shelly shale	3205	3249	44
Gray lime	3249	3279	30
Black lime and shale	3279	3285	6
Gray lime and shale	3285	3297	12
Gray lime	3297	3312	15
Lime—show oil	3312	3321	9
Lime and shale	3321	3328	7
Gray lime	3328	3334	6
Lime	3334	3357	23
Black shale	3357	3370	13
Gray lime	3370	3378	8
Shells and shale	3378	3395	17
Gray lime	3395	3408	13
Blue shale	3408	3409	1
White lime and sand	3409	3425	16
Blue shale	3425	3426	1
White sandy lime	3426	3478	52
Black lime	3478	3517	39
Black shale	3517	3523	6
Broken shale and shell	3523	3570	47
? ?	3570	3665	95
White lime	3665	4000	335

Total depth—4000 feet.

Depth of oil sand below top of Black Lime—00 ft.

Initial Production—6,000,000 cu. ft. of gas. After several shots and three or four months of gas flow, well started making oil. Now said to be making 300 bbls. daily.

CORRELATION SUMMARY.

0– 495—Canyon formation—Pennsylvanian.
495–2555—Strawn formation—Pennsylvanian.
2555–3035—Smithwick shale—Upper Bend—Mississippian.
3035—Top of "Black or Marble Falls Lime"—Mississippian.
3035–3523—"Black Lime" or Bend Lime—Middle Bend formation—Mississippian.
3523–3665—Lower Bend formation—Mississippian.
3665–to bottom—Ellenberger Limestone—Cambro-Ordivician.

State, Texas. County, Eastland. District, Ranger. Well No. 1. Farm, Jones.
Well Owner, Humble O. & R. Co. Sheet No. 1.

Formation.	From	To	Amt.	Formation.	From	To	Amt.
Soil	0	10	10	Light shale	1480	1503	23
Sand	10	25	15	Lime	1503	1518	15
Red rock	25	30	5	Blue shale	1518	1675	157
Mixed gravel	30	35	5	Brown lime	1675	1705	30
Blue mud	35	39	4	Blue slate	1705	1740	35
Gray lime	39	40	1	White lime	1740	1765	25
Blue clay	40	120	80	Blue slate	1765	1848	83
Gray lime	120	156	36	Gray lime	1848	1860	12
Blue shale	156	170	14	Blue slate	1860	1875	15
Gray lime	170	172	2	Blue lime	1875	1881	6
Blue shale	172	235	63	Sand—water	1881	1899	18
Gray lime	235	239	4	Sand—water	1899	1904	5
Blue shale	239	254	15	Sandy lime	1904	1911	7
Gray lime	254	285	31	Blue slate	1911	1915	4
Blue slate	285	400	115	Sand—water	1915	1933	18
Gray lime	400	402	2	Blue slate	1933	1935	2
Blue slate	402	432	30	White lime	1935	1947	12
Gray lime	432	440	8	Blue slate	1947	1958	11
Blue slate	440	456	16	Lime	1958	1965	7
Sand—dry	456	468	12	Blue slate	1965	1973	8
Blue slate	468	485	17	Lime	1973	1978	5
Lime—sandy	485	490	5	Blue slate	1978	2001	23
Blue slate	490	530	40	Brown sandy shale	2001	2065	64
Gray lime	530	565	35	Blue slate	2065	2401	336
Blue slate	565	570	5	Sandy lime	2401	2409	8
Red rock	570	580	10	Blue shale	2409	2465	56
Blue slate	580	627	47	Sand—dry	2465	2491	26
Lime shell	627	631	4	Blue slate	2491	2495	4
White slate	631	645	14	Sand	2495	2502	7
Lime	645	654	9	Blue slate	2502	2520	18
Water sand	654	659	5	Sand—dry	2520	2526	6
Blue shale	659	692	33	Blue slate	2526	2550	24
Lime	692	694	2	Sandy shale	2550	2627	77
Sandy shale	694	728	34	White lime	2627	2638	11
Sand	728	746	18	Sandy shale	2638	2700	62
Blue shale	746	815	69	Blue slate	2700	2760	60
Lime shell	815	821	6	Black shale	2760	2850	90
Blue slate	821	838	17	Black lime	2850	2857	7
Sandy lime	838	855	17	Blue shale	2857	2920	63
Blue shale	855	880	25	Black shale and lime	2920	2947	27
White lime	880	890	10	Black lime	2947	2973	26
Brown shale	890	900	10	Blue shale	2973	2983	10
Blue shale	900	930	30	Black shale	2983	2995	12
White lime	930	953	23	Black lime	2995	3035	40
White slate	953	961	8	Black slate	3035	3063	28
Brown slate	961	970	9	Blue snale	3063	3067	4
Lime shell	970	974	4	Black lime	3067	3071	4
Broken water sand	974	995	21	Brown shale	3071	3104	33
Blue slate	995	1030	35	Blue shale	3104	3135	31
White lime	1030	1040	10	Black shale	3135	3140	5
Blue slate	1040	1075	35	Black lime	3140	3144	4
Lime shell	1075	1078	3	Gas sand	3144	3148	4
Sand—dry	1078	1098	20	Black lime—sandy	3148	3160	12
White slate	1098	1115	17	Black lime	3160	3199	39
White lime	1115	1237	122	Brown shale	3199	3204	5
Sand	1237	1250	13	Sandy broken lime	3204	3253	49
Blue slate	1250	1325	75	Black shale	3253	3265	12
Lime snell	1325	1330	5	Black lime	3265	3285	20
Black shale	1330	1367	37	Sand—show gas and oil	3285	3290	5
Sand—dry	1367	1383	16	Black lime	3290	3309	19
Lime	1383	1394	11	Sandy lime	3309	3324	15
Sand—dry	1394	1402	8	Sandy shale	3324	3331	7
Lime	1402	1433	31	Black shale	3331	3446	115
Blue shale	1433	1440	7	Gray lime	3446	3464	18
Blue shale	1440	1450	10	Black shale	3464	3471	7
Blue shale	1450	1472	22	Lime shell	3471	3474	3
Blue lime	1472	1480	8	Oil sand	3474	3492	18

Total Depth—3492 feet.
Depth of oil sand below top of Black Lime—326 feet.
Initial Production—4500 bbls. daily.

CORRELATION SUMMARY.

0- 974—Canyon formation—Pennsylvanian.
974-2700—Strawn formation—Pennsylvanian.
2700-3148—Smithwick shale—Upper Bend—Mississippian.
3148—Top of "Black or Marble Falls Lime."

State, Texas. County, Eastland. District, Ranger. Well No. 1. Farm, Slayden. Well Owner, Prairie O. & G. Co. Sheet No. 1.

Formation.	From	To	Amt.	Formation.	From	To	Amt.
Lime	0	35	35	Slate	1220	1340	120
White slate	35	195	160	Sand	1340	1385	45
Lime	195	250	55	Lime	1385	1415	30
Black slate	250	265	15	Slate	1415	1455	40
White slate	265	280	15	Sand	1455	1465	10
Black slate	280	310	30	Slate	1465	1633	168
Broken sand	310	370	60	Lime	1633	1685	52
Black slate	370	400	30	Slate	1685	1715	30
Lime	400	420	20	Lime	1715	1835	120
Black slate	420	435	15	Slate	1835	1855	20
Lime	435	450	15	Lime	1855	1870	15
Black slate	450	510	60	Sand	1870	1910	40
Lime	510	555	45	Lime	1910	1930	20
Black slate	555	560	5	Slate	1930	2560	630
Lime	560	565	5	Sand	2560	2650	90
Mud	565	605	40	White slate	2650	2860	210
Lime	605	625	20	Black slate	2860	2900	40
Slate	625	650	25	Lime	2900	2960	60
Lime	650	670	20	Shale	2960	3105	145
White slate	670	730	60	Lime	3105	3125	20
Lime	730	750	20	Slate	3125	3200	75
Black slate	750	840	90	Black lime	3200	3210	10
Lime	840	900	60	Black shale	3210	3229	19
Slate	900	940	40	Black lime	3229	3269	40
Lime	940	980	40	Shale	3269	3300	31
Slate	980	1020	40	Slate	3300	3420	120
Lime	1020	1040	20	Lime	3420	3435	15
White slate	1040	1140	100	Brown shale	3435	3442	7
Black slate	1140	1210	70	Oil sand	3442	3456	14
Lime	1210	1220	10				

Total Depth—3456 feet.
Depth of Oil Sand below top of Black or Marble Falls lime—242.
Initial production—300 bbls. daily which 2 weeks later increased to about 4500 bbls. daily.

CORRELATION SUMMARY.

0– 980—Canyon formation—Pennsylvanian.
980–2860—Strawn formation—Pennsylvanian.
2860–3200—Smithwick shale—Upper Bend—Mississippian.
3200—Top of "Black or Marble Falls" lime–Middle Bend—Mississippian

State, Texas. County, Eastland. District, Ranger. Well No. 1. Farm, S. V. Davis. Well Owner, T. & P. Coal, O. & G. Co. Sheet No. 1.

Formation.	From	To	Amt.	Formation.	From	To	Amt.
Mud	0	5	5	Sand	825	835	10
Lime	5	45	40	Blue shale	835	1155	320
Blue shale	45	235	190	Lime	1155	1180	25
Lime	235	240	5	Blue shale	1180	1675	495
Blue shale	240	345	105	Lime	1675	1740	65
Lime	345	385	40	Light shale	1740	1845	105
Red rock	385	400	15	Blue shale	1845	2350	505
Blue shale	400	470	70	Sand	2350	2460	110
Lime	470	495	25	Dark shale	2460	2890	430
Sand	495	525	30	Lime	2890	2950	60
Blue shale	525	635	110	Black lime	2950	3000	50
Lime	635	695	60	Black shale	3000	3200	200
Blue shale	695	730	35	Shell—Oil and gas	3200	3215	15
Lime	730	825	95	Oil sand	3215	3221	6

Total Depth—3221.
Depth of oil sand below top of Black Lime—00 feet.
Initial production—1000–1200 bbls. daily.

CORRELATION SUMMARY.

0– 825—Canyon formation—Pennsylvanian.
825–2730—Strawn formation—Pennsylvanian.
2730–3200—Smithwick shale—Upper Bend—Mississippian.
3200—Top of "Black or Marble Falls Lime"—Middle Bend—Mississippian.

State, Texas. County, Eastland. District, Ranger. Well No. 1. Farm, J. H. McClesky. Well Owner, T. & P. Coal, O. & G. Co. Sheet No. 1.

Formation.	From	To	Amt.	Formation.	From	To	Amt.
Lime	0	35	35	Light shale	1180	1330	150
Yellow clay	35	45	10	Sand (salt water)	1330	1390	60
Blue shale	45	175	130	Light shale	1390	1615	225
Lime	175	215	40	Lime	1615	1635	20
Shale	215	276	61	Shale	1635	1660	25
Water sand	276	295	19	Sand	1660	1680	20
Light shale	295	354	59	Shale and lime	1680	1945	265
Lime	354	369	15	Sand (water)	1945	1967	22
Blue shale	369	380	11	Lime	1967	1990	23
Lime	380	395	15	White shale	1990	2470	480
Blue shale	305	460	65	Broken sand and shale	2470	2566	96
Lime	460	498	38	Sand—showing oil	2566	2572	6
Blue shale	498	520	22	Sand and shells	2572	2740	168
Lime	520	540	20	Black shale	2740	2920	180
Blue shale	540	570	30	Black lime	2920	2985	65
Lime	570	580	10	Black shale	2985	3035	50
Sand	580	590	10	Light shale	3035	3090	55
Blue shale	590	770	180	Black shale	3090	3204	114
Lime	770	800	30	Black lime	3204		
Light shale	800	1160	360	Oil sand	3427	3431	4
Sandy shale (water)	1160	1180	20				

Total Depth—3431.
Depth of oil sand below top of "Black Lime"—223.
Initial Production—1200 bbls. daily—Discovery well of district.

CORRELATION SUMMARY.

0– 580—Canyon formation—Pennsylvanian.
580–2740—Strawn formation—Pennsylvanian.
2740–3204—Smithwick shale—Upper Bend—Mississippian.
3204—Top of Black or Marble Falls lime—Middle Bend—Mississippian.

State, Texas. County, Eastland. District, Ranger. Well No. 1. Farm, F. Brewer. Well Owner, T. & P. Coal, O. & G. Co. Sheet No. 1.

Formation.	From	To	Amt.	Formation.	From	To	Amt.
Soil	0	20	20	Shale	1485	1516	25
Lime	20	50	30	Lime	1510	1520	10
Blue shale	50	200	150	Shale	1520	1555	35
Lime	200	210	10	Lime	1555	1565	10
Blue shale	210	225	15	Shale	1565	1640	75
Lime	225	235	10	Lime	1640	1650	10
Blue shale	235	245	10	Shale	1650	1660	10
Lime	245	255	10	Lime	1660	1695	35
Blue shale	255	315	60	Shale	1695	1702	7
Lime	315	324	9	Water sand	1702	1740	38
Shale	324	330	6	Shale	1740	2110	370
Lime	330	335	5	Gas sand	2110	2125	15
Blue shale	335	360	25	Shale	2125	2310	185
Lime	360	380	20	Sand	2310	2335	25
Shell	380	485	105	Shale	2335	2365	30
Sand	485	495	10	Sand	2365	2420	55
White shale	495	500	5	Shale	2420	2470	50
Shell	500	550	50	Shale	2470	2480	10
Blue shale	550	610	60	Sand	2480	2490	10
Water sand	610	620	10	Shale	2490	2550	60
Blue shale	620	630	10	Sand—broken	2550	2610	60
Water sand	630	650	20	Black shale	2610	2830	220
Blue shale	650	610	60	Black lime	2830	2865	35
Lime	660	665	5	Lime—broken'—black	2865	2890	25
Blue shale	665	740	75	Black shale	2890	2960	70
Lime	740	760	20	Lime—broken—black	2960	2965	5
Brown shale	760	770	10	Brown shale	2965	3000	35
Shell	770	1210	440	Gray shale	3000	3010	10
Sand	1210	1230	20	Shale	3010	3041	31
Slate	1230	1260	30	Black shale	3041	3111	70
Brown shale	1260	1300	40	Black lime	3111	3140	29
Lime	1300	1305	5	Shale	3140	3170	30
Shale	1305	1450	145	Lime	3170	3185	15
Lime	1450	1485	35	Black shale	3185	3260	75

State, Texas. County, Eastland. District, Ranger. Well No. 1. Farm, F. Brewer. Well Owner, T. & P. Coal, O. & G. Co. Sheet No. 2.

Formation.	From	To	Amt.	Formation.	From	To	Amt.
Shell—lime	3260	3265	5	Brown lime	3274	3289	15
Black sandy shale	3265	3274	9	Oil sand	3289	3298	9

Total Depth—3298.
Depth of Oil Sand below top of "Black Lime"—178 feet.
Initial Production—2200 bbls.

CORRELATION SUMMARY.

0– 485—Canyon limestone—Pennsylvanian.
485–2610—Strawn formation—Pennsylvanian.
2610–3111—Smithwick Shale—Mississippian—Bend (Upper) formation.
3111—Top of Black or Marble Falls Lime—Mississippian—Middle Bend.

State, Texas. County, Comanche. District, Northern Comanche. Well No. 1. Farm, Knowles. Well Owner, Tex-Penn Oil Co. Sheet No. 1.

Formation.	From	To	Amt.	Formation.	From	To	Atm.
Clay	0	20	20	Sand	1060	1080	20
Conglomerate	20	40	20	White slate	1080	1100	20
White mud	40	50	10	Brown slate	1100	1175	75
Gravel	50	55	5	White slate	1175	1200	25
Lime	55	66	11	Black slate	1200	1220	20
White slate	66	93	27	Shell	1220	1230	10
Sand	93	110	17	White slate	1230	1300	70
Brown slate	110	160	50	Black slate	1300	1340	40
White slate	160	185	25	Brown slate	1340	1400	60
Lime	185	200	15	White slate	1400	1450	50
Sand	200	225	25	Shelly lime	1450	1500	50
Brown slate	225	275	50	White slate	1500	1540	40
Sand	275	300	25	Shelly sand	1540	1600	60
Black slate	300	350	50	White sand	1600	1650	50
Sand	350	390	40	Gray lime	1650	1680	30
White slate	390	395	5	Sand	1680	1720	40
White sand	395	440	45	White sand	1720	1730	10
White slate	440	445	5	Sandy lime	1730	1760	30
Sand	445	525	80	Sand	1760	1870	110
Slate	525	550	25	Brown shale	1870	1895	25
Lime shell	550	570	20	Lime	1895	1900	5
Slate	570	580	10	Sandy lime	1900	1940	40
Lime	580	600	20	Brown slate	1940	1950	10
Slate	600	605	5	Sandy lime	1950	2010	60
Lime	605	615	10	Black slate	2010	2030	20
Slate	615	645	30	Sand	2030	2050	20
Lime	645	655	10	Lime	2050	2080	30
Slate	655	705	50	Black slate	2080	2100	20
Sand	705	720	15	Sandy lime	2100	2120	20
Brown slate	720	800	80	Brown shale	2120	2140	20
White slate	800	850	50	Sandy lime	2140	2170	30
Brown slate	850	900	50	Sand	2170	2210	40
Lime	900	910	10	Black slate	2210	2215	5
White slate	910	940	30	Brown slate	2215	2430	215
Lime	940	950	10	Brown shale	2430	2460	30
White slate	950	970	20	Black slate	2460	2560	100
Sand	970	980	10	Gray lime	2560	2670	110
Brown slate	980	1050	70	Black lime—sandy	2670	2690	20
Sand	1050	1060	10				

Total Depth—2690 ft.
Depth Oil Sand below top Marble Falls Lime—130 ft.
Initial Production—4500 bbls.

CORRELATION SUMMARY.

0–2210—Strawn formation—Pennsylvanian.
2210–2560—Smithwick shale—Upper Bend—Mississippian.
2560—Top of "Black Lime" or Bend Lime Middle Bend—Mississippian.

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SOME PROBLEMS OF INTERNATIONAL READJUSTMENT OF MINERAL SUPPLIES AS INDICATED IN RECENT FOREIGN LITERATURE.

ELEANORA F. BLISS.[1]

INTRODUCTORY.

During the four years in which the greatest nations of the world have been locked in a struggle for military supremacy, there have been many thinking men both behind the fighting lines and within the camps of the belligerents who have realized the rôle played by economic and commercial activities in the evolution of that international status that was inevitably bound to result in the most terrific human explosion that has been witnessed in the history of mankind.

It is a fact that nations, while in truth forming one great world family, yet are and always will be actuated by the same individual interests and selfish desires that are bound to be an actuating principle in the lives of those who make up any human family. By realization and appreciation of the fact that as in a family, human equity demands the recognition and development of the rights of the individual, so in the world international justice and polity demand the right of individual nations to the means of sustenance and growth, we shall arrive at a conception of the much longed for "world democracy."

In practice this right cannot be actually attained. By virtue of circumstances certain individuals and nations are more highly endowed than others with nature's gifts. While the ideal of democracy that all men are and of right should be free and equal, may, and doubtless will, remain to the end of time unattainable, yet the principle of democracy as rightly and faithfully applied demands that those individuals or nations who have attained a

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certain supremacy in the affairs of mankind shall watch over the welfare and safety of those who must struggle under the handicap of a lesser share of nature's endowments. In the life of a democratic state there will always be two factors which will combine to keep the balance true and to prevent the undue ascendancy of one individual to the exclusion and to the undoing of others. They are: first, the disinterestedness of human nature which has led many a man to give up not only his life but also the chances of so-called personal aggrandizement for the sake of benefiting other individuals and the race at large; second, the self-interest of human nature which leads every man to struggle against those interests and ascendancies which he conceives to be prejudicial to his own personal welfare. It is only by a true appreciation of these two predominant influences in the lives of nations and mankind that we shall be able to exercise the curb in international relations that is of paramount importance if we are to prevent a repetition of the struggle of the past four years.

GERMANY'S METHOD OF COMMERCIAL EXPANSION.

A clear exposition of some of the conditions and policy that led up to the recent war is shown in a book published during 1918.[2] "Germany's Commercial Grip on the World," by M. Henri Hauser, a professor in the University of Dijon, was written in order to bring to the French-speaking public the realization of Germany's business methods as applied to her foreign trade, the business methods by which she had acquired before the war a commercial ascendancy, little realized by the average business man in countries not apparently within the sphere of German influence, and completely unappreciated by the unsuspecting consumer, who regarded the trade mark "made in Germany" with an amused toleration frequently bordering on contempt.

Hauser's book is a distinctly fair and unbiased attempt to set before the mercantile and also the lay reader the means by which

[2] Hauser, Henri, "Germany's Commercial Grip on the World," Scribner, 1918.

Germany had made for herself that domination in the commercial world which is the undoing of all real international democracy. He gives due credit to German economic virtues, such as her increase in population, her industry, her discipline, and her submission to authority. In his analysis he emphasizes four fundamental instruments in the attainment of German commercial power, the bank system, the cartel, the transport organization, and the rôle of the state in encouraging and supporting specialized industries.

The Bank System.—By the combination in German banks of the three functions of deposit, credit and finance these organizations have been enabled to play a part in the promotion of industrial enterprise which in our own country is reserved for the individual financier, for the banker rather than for the bank. In order to render their export trade independent of British and French financial channels, the various large German banks began as Hauser aptly phrases it "to swarm" and in a comparatively short time a network of German banks was established in South America, Italy, Greece, Turkey and Asia Minor. The dangers attendant upon such a wholesale participation of the banks in industrial promotion resulted in some heavy losses and caused the banks to adopt a system of grouping by which each great bank supports several undertakings and on the other hand each large financial enterprise is backed by a group of several banks. This grouping of banks is rendered possible by a mutual interchange of paper, a method which however advantageous from the point of view of business promotion is nevertheless susceptible of most dangerous collapse in the event of sudden slump. The relation of the original German bank to the home industry is reproduced in the relations of the subsidiary foreign banks to the importer and exporter. They supply the manufacturer with credit which enables him to furnish his customers with the particular type of long-term payment best suited to their convenience. Moreover, the practice of gradually withdrawing German capital from overseas banks after the institution had been successfully manipulated into German control has resulted in the

financial domination of foreign countries without the locking up of home capital to any large extent. The loans made to a foreign state are repaid in orders, insurance companies instituted abroad replace their reserves in German securities, in short the trend of capital is all towards Germany. Such a condition of affairs leads to what even a German was forced to characterize as "an unhealthy rise in industry" and furnishes the possibility of a phenomenal and predominating industrial expansion.

The Cartel System.—The celebrated cartel system to which Germany owes so much of her industrial efficiency is characterized by Hauser as a combination of producers for the coöperative sale of their output or of certain classes of their output. It differs from our trusts in that the individual enterprise retains its entity, but shorn of all independence in the sales transaction which is either carried out by the sales bureau or else regulated as to price, geographic limitation, quota of production of individual factories and so forth. There are two factors which check the domination of the cartel. The larger establishments such as Krupp escape its domination because they are able through their far-reaching interests to supply themselves with all the essentials of their industry within their own domain. Moreover, the changeable nature of the cartel which adapts itself to and changes with the condition of the market renders it not so much an iron-clad yoke as an adjustable harness by which competition is restrained, over production regulated, and lowering of prices prevented, provided the adherents of the cartel submit to the rigid discipline of its authority. Hauser explains how the cartel came into being as the inevitable outcome of the period of over production, under consumption, and lowering of price which accompanied and followed the financial depression of 1873. At that time competition was so intense as to be well nigh the extermination of many industries and the cartel which was instituted more or less as a self-protective measure has later, by its introductions of "dumping" on foreign markets, been enabled to control and correct the conditions in the home market which have always been both a stimulus to German industry and a

menace to foreign competition, namely, the ability of the German factory to over produce. By "dumping," the German manufacturer gets rid of his surplus production on the foreign market at a price which would be disastrous were it not for his ability to rehabilitate himself by means of the higher domestic price set and maintained by the cartel. Through the cartel he is also enabled to acquire an export bonus on the price of raw materials destined for ultimate export in the form of finished product.

Transport.—Additional facilities are furnished to the export trade by the special transport rates on both railway and steamship lines which not only enable the manufacturer to get his goods to foreign destinations at sometimes only one quarter more than he would pay to ship the same commodity between Breslau and Hamburg, but also offer an attraction to foreign shippers to consign their merchandise via German railways or German ships at greatly reduced freight charges. In other words by means of the state operation of railways the government is enabled to practice a sort of railway dumping by which the transport charges can be reduced for the benefit of the export trade or of foreign traffic.

Rôle of the State.—M. Hauser emphasizes the function of the German state in economic domination through its ownership of railways, and its military and naval consumption, together with its hold on the electrical industry acquired by its monopoly of canal towage.

In regard to the cartel the state finally resolved to make a virtue of necessity by adopting a policy of toleration and supervision which wound up in some cases by the state absorbing the cartel as in the case of the loose jointed union between the government and the coal syndicate, or by the State organizing the cartel as in the case of the potash syndicate which owed its existence in the first place to the desire of the government to regulate the production of the Prussian Stassfurt mines and to keep the price sufficiently high to preserve for the nation the material required for agriculture. The potash syndicate holds a unique

position among German cartels owing to the fact that German potash production has resulted in the largest national monopoly known among minerals. The aim of the Kalisyndikat was not to encourage export by reduction in prices on the foreign market but rather to raise the export prices and thus by a system of reverse dumping to reserve material for home consumption.

Conquest of Foreign Markets.—In the last section of his book Hauser deals rather briefly with German methods for conquest of foreign markets. He emphasizes the systematic study of the individual market and clientele by which the German exporter arrives at a complete understanding of the requirements and possibilities of their export business. He notes the acumen and psychological shrewdness of the German commercial traveler who is constantly on the spot, always anxious to satisfy his customer, always ready to do business honestly if possible, dishonestly if necessary. He calls attention to the exportation of a business house where it seemed that foreign trade could be better handled through the direct management of an overseas branch of the German industry, and he laments uncontested intervention of the German middleman in the conduct of French trade. He acknowledges the cleverness of German propaganda and publicity methods by which they handle an enormous and skillfully manipulated self-advertising scheme. Most important of all he explains the final step in German exportation which is the transplanting of factories themselves into foreign territory. He disposes of the fallacious argument that such export of industry enriches the country so penetrated by showing that, as in the case of the foreign branches of German banks, capital is not actually transferred from the German source to the foreign country, but on the contrary the minority of the share of capital is frequently the German portion. Nevertheless, the German skillfully manipulates the distribution of interests so as to retain a controlling hand in the management and in addition he obtains a corner on the foreign raw materials in which he is often deficient at home. A good example of this was the Thyssen control of Normandy blast furnaces through his institution of a factory and railway

in association with the iron mines in Normandy. In return for his cession of all except 20 per cent. of his control of the factory to so-called French interests he acquired the right to purchase the complete supply of the Norman furnaces. The last step in exportation is taken in order to escape burdensome taxes on finished products, machinery, dyes, etc., and the German exports his semi-finished materials and assembles and perfects them in the country of their ultimate destination.

Economic Factors in Causing War.—In conclusion Hauser sums up the conditions which were potent factors in causing the recent war—first, the sudden and daring rise in German industry which has necessitated the organization of a drastic cartel system to combat the dangers of unlimited competition entailed by over-production; second, the further relief of this congestion of over-production by means of an over-developed system of foreign dumping; and third, the temptation to stabilize her somewhat shaky financial foundation by the accession of foreign capital which it was becoming increasingly difficult to attain by peaceful methods. In short, Germany's commercial grip on the world which had strengthened speedily and yet to a large extent unobserved, had finally reached a point where its future strength was becoming imperiled by the growing realization of other nations and their consequent restlessness under the yoke. Such an autocratic and iron-clad policy cannot continue forever unchallenged because there exists in the world that inherent democracy of nations, perchance actuated by fundamental self-interest, which at all costs insists upon maintaining to individual nations the right to exist.

The Russian opinion of German methods is briefly set forth in a small volume by Dr. Paul Gourvitch[3] written in English and published in New York in 1917. It also is a fair and unbiassed description of German commercial power. It gives due credit to the fact that much of her supremacy was due to her own energy and foresight in the conduct of her exporting business by which

[3] Gourvitch, Paul, "How Germany Does Business," B. W. Huebsch, New York, 1917.

she was often enabled to supersede the laxer and more "hit or miss" methods of her foreign competitors. Gourvitch describes in detail the importing and exporting of credit. While giving due credit to German skill and enterprise in the manipulation of foreign markets he does not fail to note their dishonest and unscrupulous methods in the matter of imitation and counterfeiting in order to replace the commodities of their competitors by their own goods sold at lower prices.

GERMAN POST-WAR TRADE.

The volume by Herr S. Herzog[4] which was published in translated form about two months ago under the auspices of Herbert Hoover, Vernon Kellogg, and Frederic C. Walcott, called "The Future of German Industrial Exports," represents the ideas of a well-known German engineer on the subject of reëstablishing after the war the same methods of commercial supremacy that led to the recent catastrophe. His avowed aim is to regain by strategic means the former commercial position of Germany. He definitely states that since the par value of treaties is nil, any commercial treaty formulated after the war will be worthless. He contends that the treaty will be but the preliminary to an economic warfare having for its object the mastery over German industry. He states that Germany's industrial exports must go on. In order to do this the essential structure of German industry is to be divided into two classes, the first known as "protective industries" representing both raw and finished products of German origin which are absolutely indispensable to some foreign country. These products are to be placed under a special state control by which they are to be fostered and supported so that it will be possible without killing the industry to place an absolute embargo upon its market in any foreign country which has showed injurious discrimination against Germany. The second class comprises those auxiliary industries which furnish to the protective industries the necessary raw materials. These

[4] Herzog, S., "The Future of German Industrial Exports," Doubleday Page and Co., Garden City, New York, 1918.

auxiliary industries are obliged to furnish the necessary raw materials at such low cost that it is possible for the protective industry to remain always in control of the market. The secondary industry will be reimbursed in the course of time by a percentage share in the earnings of their customers or else through the general guarantee fund which it is proposed to institute in order to supply the necessary reserve capital that will enable the protective industries to cut their prices below competition and to submit to embargoes on their market while they produce a stock surplus. It was also proposed to institute a Central Sales Bureau which should have complete charge of the foreign sale or embargo of the output of the protective industries.

His scheme as elaborated is chiefly a matter of domestic organization which had already reached such an advanced point in German industry. Its weak point is that Germany is dependent for many raw materials upon foreign sources. But it must be remembered that this book was written in the confident expectation of a complete German victory by which she would be in a position to dictate her terms to the world. What these terms would have been is stated in Chapter II. with a candor for which we cannot help but be grateful since "forewarned is forearmed." The terms of their commercial treaty would have entailed assurance of raw materials at suitable prices, prevention of specially discriminating or injurious foreign tariffs, assurance of all concessions and protection to German interests that are conferred upon any other nation, and official recognition of the various federations that were to furnish the modus operandi of the schemes outlined above (for the protection of German interests). Herzog then goes on to indicate that it would be well to demand exclusive favoritism of Germany in certain points, after carefully eliminating all possibility of any discriminative favoritism against Germany. He demands for her unlimited right to secure raw materials abroad without any export restriction in the country of origin, he insists upon the right of supervision over German plants abroad that are furnishing raw materials to the protective industries, he stipulates for control of foreign freight

rates, he eliminates all foreign concessions which could benefit other countries to the exclusion or disadvantage of Germany, and he demands a special guarantee to cover German capital invested in foreign countries. In short he demands not only an open door for German trade but also all kinds of special provisions operating to the benefit of German trade in order that she may entrench herself safely behind an invincible bulwark of commercial supremacy.

READJUSTMENT OF MINERAL SUPPLIES.

A commercial domination by any one nation is obviously unjust and is as we have seen one of the most potent reasons for the recent war. We cannot escape from the fact that in the interrelation of nations, certain countries are bound to play a dominant part in the production or in the manufacture of certain commodities. The German control of potash and the Chilean output of nitrates are the largest examples of so-called world monopolies of minerals. Nevertheless, in the last four years even these two most formidable commercial bogies have been robbed of some of their terrors.

Potash.—We have found to our own surprise how possible it is for us to get along without German potash. The possibility of decreased consumption, various new sources as well as the increased possibility of recovery from waste sources in blast furnace and cement plant gases have shown that for a considerable period at least we are not absolutely helpless without the German supply. But commerce which takes the place in the life of a nation that breathing does in the life of an individual must, in order to attain eventually the best results, be like breathing, a natural process.

In the present stage of the world's development the natural source of supply for potash lies in the German deposits and from that supply we have a right to expect our maintenance. It is a debt which Germany owes to the democracy of nations and which she must pay with equity and, if not voluntarily, then under protest. In this connection it should be noted that the reserves of

Alsace-Lorraine have been computed as sufficient to furnish the world with potash for 300 years; have been considered to be about equivalent to those of the Stassfurt deposits, while it appears likely that reserves of considerable magnitude may be developed in northeastern Spain. So much for potash which, though important by reason of its entire localization within the confines of what was German territory, is not one of the most essential of mineral commodities.

The Important Mineral Commodities.—The accompanying figures show in diagrammatic form the relative control by the United States, Great Britain, France and Germany of the five most important mineral commodities. The first column represents the percentage of the world's output which is produced by these countries and by their colonial possessions. The second column represents the porduction control of raw material exercised by these four countries, as expressed by their domestic production plus their imports. The third column represents the consumption control of finished products as expressed by the amount of raw material retained in the country after export.

The United States leads in both production and production control of all five minerals. Great Britain is equal, or superior, to Germany in production of all except iron ore in which she has only half the output of Germany. France is plainly deficient in all five essential minerals. Therefore, Germany and Great Britain divide the control of production among the three European nations.

In the actual industrial control of raw materials, however, the matter is quite different. The United States still leads as would be expected from her large production; Germany has plainly taken the foremost place in all except the lead industry. She controls by means of her imports, as much fuel as Great Britain and about twice as much iron ore, copper and zinc; France is far behind. The actual amount of fuel consumed for domestic and industrial purposes in Great Britain and Germany is nearly the same, but Germany's consumption control of crude copper,

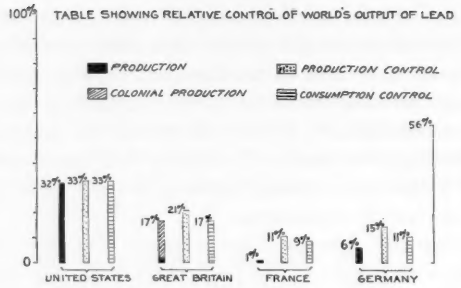


FIG. 8.

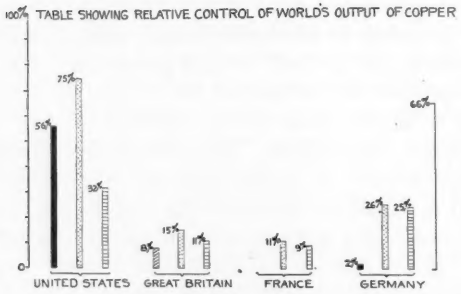


FIG. 9.

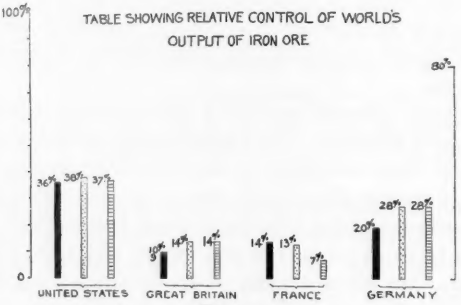


FIG. 10.

FIGS. 8, 9, 10. Dominant control of the world's output of lead, copper, iron-ore of mineral products. Aggregate control shown by vertical line on right.

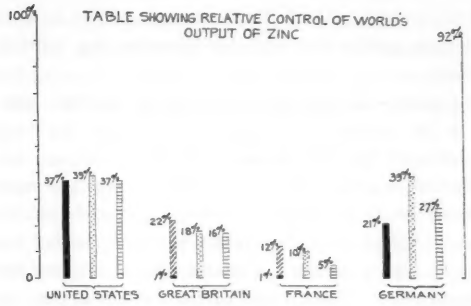


FIG. 11.

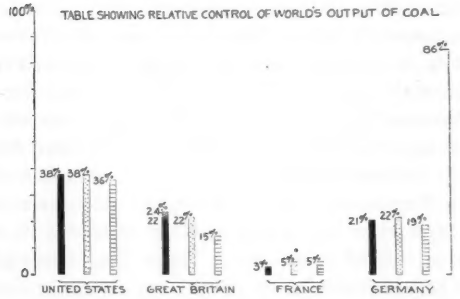


FIG. 12.

FIGS. 11, 12. Dominant control of the world's output of zinc and coal. Aggregate control shown by vertical line on right.

zinc and iron is almost double that of Great Britain, while the industrial consumption of France again lags far behind.

An inspection of the scale on the right of the diagrams brings out the fact that these four countries control in their production about nine tenths of the world's coal and zinc; four fifths of the world's iron ore; two thirds of the copper and over half the lead output of the world. A glance at the columns showing control of raw materials indicates that the world's industrial market of copper and zinc, and nine tenths of the market of coal, copper

and lead, is in the hands of these countries. The balance of industrial power before the war lay between the United States and Germany.

Coal and Iron.—In the case of France nature has dealt hardly with her in the matter of mineral resources and as long as she remains deficient in coal she will never become an industrial factor. Before the war the balance of fuel was too much upon the German side of the scale. Much of Europe's chance for a stable and enduring peace lies in an equitable redistribution of her coal and iron supplies. Various official suggestions from the governments of France and Great Britain appear to favor the restitution of the Lorraine basin to France, thereby transferring almost three fourths of Germany's total of iron ore output. The necessary coke to handle this amount of ore is to be found partly by annexing the Saare district and partly by drawing on the high grade coal fields of Westphalia. In case the Rhenish Westphalian syndicate should refuse to export coal to Lorraine it is proposed that France should establish a reciprocity treaty with England whereby she can draw British coal in exchange for French iron ore. It is urged at the same time that iron ore exports to Germany should be restricted in order to prevent possibility of future war. These ideas meet with favor in various British journals.

Some German notions of a post-war distribution of coal and iron have come to us through French sources. It seems probable that they are a fair representation of prevalent opinion in the German commercial world. A memoir addressed to the Imperial Government in December, 1917, by the Association of German Iron and Steel Industries and by the Association of Metallurgists is in favor of peace without annexation except for the acquisition of Briey which they claim would assure to Germany in the next war considerable resources in domestic ore. "The Wirtschaftszeitung of the Centralmächte" calls attention to the fact that the annexation of Briey would cause unfortunate competition with the German blast furnaces already in operation. It might be better to allow France to retain possession of Briey and

to send her ore to Germany. It appears that Germany has contemplated the possibility of exceeding the American iron and steel production by means of the resources of the Briey basin and by the further development of German interests in Normandy.

A clear exposition of the French attitude towards the coal and iron problem by G. DeLaunay[5] has unfortunately never been translated into English. The second part of the book deals with the treaty of peace and post-war conditions. He discusses the coal situation of Europe and calls attention to the fact that the production of Germany had increased nearly 20 per cent. in the five pre-war years while the production of Great Britain had remained nearly stationary during the same time. He emphasizes the excellent quality of the coal of Westphalia, which amounts to two thirds of the actual coal production of Germany (lignite excluded). He notes the low cost of extraction of coal in Germany due to the natural ease in working their coal deposits and to the installation of machine cutting in German mines. To this natural richness in coal he ascribes the longing of the Germans to possess not only the iron ore of German Lorraine but even the share which remained to France in the field of Briey and Longwy.

He then acknowledges the absolute deficiency of France in coal and calls attention to the fact that her reserves are far surpassed by those of England, Belgium and Holland. He discounts as impractical the possibility of further important reserves being found beneath the Paris basin and he disposes of France's water power as an inadequate substitute in addition to the fact that the electrometallurgy of iron is not yet available for any but special purposes. He, therefore, states that France is dependent for necessary coal upon the approaching treaty. The production of Belgium is not sufficient to supply the deficit, and importation from England would not be profitable. He will not allow that France should be relegated, for lack of sufficient raw materials, to the position of a manufacturer of only highly refined and

[5] DeLaunay, L., "France-Allemagne," Librairie Armand Colin, Paris, 1917.

specialized finished products, justly contending that she has shown in the past war that she is far from being in the position of a dying nation which must be sustained by unnatural and selected industries. He claims on the contrary that she is entitled in return for her noble efforts to sustain herself against invasion to have a certain reparation for the injuries which have been dealt to her by nature in her scant endowment of mineral wealth.

He demands therefore the restitution to France of Alsace-Lorraine with her 21,000,000 tons of iron ore, together with the Saare basin and its 17,500,000 tons of coal and complete freedom to utilize the ore so acquired.

He then proceeds to examine what would be the situation if France in order to paralyze the iron and steel industries of Germany should refuse to export her iron ore to the Germans. The pre-war production of iron ore in French Lorraine was 19½ million tons, and her exports 8 million tons. By adding to this the 21 million tons of German Lorraine France would have at her disposal 40½ million tons of ore, as opposed to 11½ millions which she smelted in 1913. For the additional ore almost 31 million tons of coal would be required if 5 million tons of ore were exported to Belgium and Holland. The 1913 production of France in coal was 41 million tons and her consumption, according to De Launay, was 62 million tons, leaving a deficit of 21 million tons. The requirements of the numerous blast furnaces already in operation in German Lorraine would bring this deficit up to 52 or 53 million tons. The annexation of 17½ million tons of coal in the Saare basin would still leave about 36 millions unaccounted for. Out of 21 million tons imported in 1913, 10 millions came from Great Britain and 4 millions from Belgium, the remaining 7 millions chiefly from Germany.

De Launay contends that neither Great Britain nor Belgium could furnish much more than her pre-war quota because of the insufficient supply of Belgium and the difficulties attendant upon the long haul from England to the Lorraine furnaces. It would be necessary then to purchase about 22 million tons of coal from

Germany and he insists that the elimination of commercial relations with Germany is out of the question.

France is face to face with the problem of either exporting ore from inability to smelt or of buying coal and coke from Germany and maintaining her furnaces at the risk of overproduction or else of closing her mines. In other words, France would then be contending with the problem that beset Germany during the years of her phenomenal industrial rise only with this difference, that whereas Germany had a great temptation to overproduction with her richness of combustibles, France has to go abroad to search for the means of maintaining her furnace output. De Launay does not take kindly to the idea of restricting mine output for, although he acknowledges that there are advantages in holding reserves, he also maintains that the progress of metallurgy may, in a comparatively short time, displace these phosphorus ores of Lorraine for some other type such as siliceous or arsenical iron ore. He advocates the exportation of ore on a reciprocity basis to Great Britain. But he acknowledges that this would not dispose of the large stocks of iron ore which France would have to offer.

France must sell iron ore to Germany, provided that she receives in exchange for it the coal that she requires. This exchange should be made under favorable conditions such as those assured to Germany by the treaty of Frankfort in connection with the textile industries of Alsace. The peaceful interchange of commodities should not begin until after a period during which Germany should furnish France with coal without compensation and during which the exports of French iron ore should be completely closed to Germany in order to paralyze certain German factories before they could revert from a war to a peace basis of production. He would, moreover, reserve to France the right to place at all times in the future such embargoes on exports to Germany as she might deem necessary in order to prevent the recurrence of war.

De Launay is not blind to the fact that the ultimate disposition of Alsace-Lorraine is complicated by the German nationality of

one part of her people. Moreover, he appreciates the domination of German interests in the iron and salt syndicates, etc., and he realizes that even if it were possible to rid these institutions of their German domination they would still be controlled not by French but by various foreigners, Swiss, Swedes and the naturalized American Jews of Frankfort. The suggested solution of this problem is the expropriation of the German inhabitants of Alsace-Lorraine. The industrial syndicates are to be combined into a syndicate of the Gewerkschaft or localized type, as opposed to the Gesellschaft or imperial type. That is to say they are localized under one controlling power only exercised in Alsace-Lorraine. The directors and stockholders of these new companies are to be entirely French or members of allied nations. In order to enforce this the stock is to be all registered. He acknowledges that in spite of these safeguards it is likely the Germans will obtain a surreptitious hold upon the administration through factitious shareholders. It would not be likely, however, that Germans could continue to exercise such a complicated and costly method of supervision in Alsacian affairs. It is more probable that they would retire and construct new factories in the Ruhr district.

In conclusion De Launay insists that without coal France can not handle the increased iron and steel industries consequent upon the annexation of Alsace-Lorraine, that the necessary coal can not be obtained at sufficiently low price from Great Britain on account of transportation cost, that the factories of France could not work up the crude products of the Lorraine ores and that the raw materials would necessarily continue to be exported to Germany. In case they are sent to Germany, subject to customs duties, the iron and steel of Lorraine would not compete with the products of the Luxembourg furnaces which pay no duties. He, therefore, stipulates that the portion of the iron and steel output which was formerly absorbed by the German market should be admitted to Germany duty free. He also warns his readers that the German iron and steel industries will never be extinguished as long as it has access to the foreign ores of

Sweden and as long as it exercises control over the Duchy of Luxembourg.

A note of warning is sounded by Dr. C. W. MacFarlane[6] in "The Economic Basis of an Enduring Peace" published in 1918. He goes farther than De Launay and suggests the expropriation of the coal fields of Westphalia in order to secure to France the necessary fuel for her industries. He disposes of the problem of the assimilation of the German people of Westphalia by stating that France is more successful in dealing with her colonies than Germany and he claims that the German population would be contented to become citizens of an industrial republic rather than of an absolute monarchy. Whether these reasons would be sufficient to insure the successful assimilation into France of a population more essentially German than Alsace-Lorraine is French is a matter of some doubt, but he realizes that by depriving Germany of 75 per cent. of her available supply of iron ore and by assigning to France 60 per cent. of German coal in the district of Westphalia we would completely wreck Germany as an industrial power. He therefore proposes to turn over to Germany the control of Turkey in Asia in order that she may rehabilitate her iron and steel industries with the high grade magnetites of Asia Minor. This solution of the difficulty with its necessary concomitant of an all rail route between Germany and Asia Minor, with a tunnel under the Bosphorus, and a proposed federated Balkan state under international guarantee, will not appeal to the many people who conceive that the increasing participation of Germany is near eastern affairs is already a distinct menace. And if it has proved impossible to assure the integrity of a nation like Belgium which is a well established unity we may be pardoned for declining to assume the responsibility of welding the seething Balkan turmoil into any sort of federated state under an international guarantee. Nevertheless, MacFarlane's book serves a needed purpose by pointing out what we are liable to forget in our natural desire to see the industries of France placed

[6] MacFarlane, C. W., "The Economic Basis of an Enduring Peace." Geo. W. Jacobs and Co., Philadelphia, 1918.

upon a stable basis, namely that by depriving Germany of practically all her iron and by annexing to France so much of German coal that there shall be no commercial interdependence between France and Germany, we are transferring the predominance of industrial power from Germany to France. In fact, we would transfer it to such good effect that we would relegate Germany to a position of industrial impotence at the same time that we placed an undue industrial supremacy in the hands of France, who would then control by her production two and a half times as much iron ore as Great Britain and almost six times as much as Germany. Such a situation would not be entirely free from danger to the future peace of Europe.

Tungsten.—Through French sources have come various interesting ideas for the post-war disposition of other minerals less important than iron and coal. It is unfortunate that we have received so far no information concerning their ideas on the subpect of copper, lead and zinc. Great hopes are entertained by the French government for a post-war tungsten industry that would lie chiefly in the hands of the allies. The position of the ferrotungsten industry before the war was one of the most striking examples of Germany's industrial domination of a raw material in which she is herself essentially lacking. In 1913 Germany produced only about 1 per cent. of the world's output of tungsten ore reckoned in terms of 60 per cent. tungstic acid. Yet through her imports she controlled over 60 per cent. of the world's output. Great Britain including her possessions produced 37 per cent. of the world's output yet she was dependent entirely upon Germany not only for ferro tungsten but also for her tungsten steel tools, which even though purchased through English firms were derived from German manufacturers. France's production of 1913 amounted to 12 per cent. of the world's output and in addition to this she controlled the production of the French mine of Bourralha in Portugal and possessed an interest in the Bolivian enterprises. Owing to her development of water power she had a pre-war production of ferro tungsten, though it is certain that she was not at that time in a position to compete

with the German market of ferro alloys, still less with their output of high speed tools. Her comparative poverty in this respect is shown by the statement in *La Metallurgia* for April 30, 1918, that her consumption of ferro tungsten had increased from 250 to 1,800 tons as the result of the war. The suggestion is made that in the future tungsten ore should only be sold to Germany at very high price in order to maintain the high price of tools. On account of the difficulty of successfully concentrating the tungsten business on a financially profitable basis it is suggested that the tin and tungsten industries might be organized into a combination which would increase the power of the allies in the Bolivian field, at the same time frustrating the activities of Germany in that respect.

The English ferro industry has reached such a point that after the war it will be able to handle all the British production of molybdenum, which is nearly one third of the world's output. From French sources comes the suggestion that the four French ferro producers can, by reason of their cheap water power, handle all the tungsten or molybdenum which the British might find difficult to dispose of on account of the high cost of production in time of peace.

Vanadium and Uranium.—Owing to the American control of the vanadium output the American Metal company will become the center for a combination which should dispose of the world's supply of vanadium in such a way as to eliminate Germany's participation in the ferro-vanadium business and to relegate her manufactures requiring vanadium steel to an unimportant position. Since the United States is the principal producer of uranium ores it would seem possible to combine the management of the vanadium and uranium output so as to place the uranium business on a self-supporting basis, not dependent upon state assistance which is an artificial way of sustaining an industry. On account of the possibility that German reserves of uranium may be increased by further exploitation the French writers urge upon the allies the necessity for vigorously pursuing their efforts to keep the monopoly of these ores in their own hands.

Antimony.—Although it might seem at first sight that the control of the antimony market would lie in the hands of the Allies on account of the fact that most of China's production is treated in the smelters of England, France and Belgium yet the fact that in January, 1917, the Central Powers no longer showed evidences of the antimony shortage from which they suffered at the beginning of the war would indicate that they had succeeded in increasing their resources to a considerable extent doubtless by exploitation of the Turkish deposits. It is, therefore, probable that after the war they would be self-sufficient for the small peace time requirements of antimony.

Tin.—In regard to the tin industry which has hitherto remained almost exclusively under the domination of the Metallgesellschaft and the Dutch market which handles one sixth of the world's production, French writers indicate the necessity of organizing the interests of the Allies and of those neutrals who are outside the sphere of German interests. The British empire is the principal producer of tin and her enterprises are becoming gradually more coherent while she is ridding herself of the dominant Anglo-Holland interests. It is easy for her to increase her production, to extend her smelters in the British East Indies, and also to establish in Australia à hold which should stamp out growing German influence in that country. She would in time be able to dominate the mines of Siam by extension of her interest in the Malay peninsula. Bolivian mines should be carefully protected from German influences. The French industry should be stimulated. Belgium might readily enter the field of the smelting and the United States occupies a position of growing importance on account of her de-tinning industry. The Allies could easily recover from tin plate scrap in English, French and Italian works enough to supply all their needs in tin chloride, and in addition have 40 to 50 thousand tons of steel available for use by refusion.

Phosphates.—As far as phosphates are concerned the Allies have a virtual monopoly of the situation on account of the large production of the United States and of the French possessions

in northern Africa. The principal German sources of supply formerly lay in the Marshall Islands and in the phosphatic slags furnished by the basic iron industry of Lorraine. The latter source will be transferred to the French with the accession of Alsace-Lorraine and the output of the Marshall Islands is now controlled by an English company which finds its market chiefly in Japan and Australia. Germany might find a supply in the guanos of South America. The Peruvian deposits are however controlled by an English company and the guanos of Oceania are in the French or British islands, so that the only deposits available for Germany are those of the Patagonian coast of the Argentine Republic amounting to only 28,000 tons in 1913. Bone phosphate and phosphate extracted from animal refuse is a considerable industry in Germany and a prominent company for the production of chemical fertilizers in Paris was under German supervision, a fact which is noted by the French as requiring action on the part of the French government. In general the phosphate apportionment is susceptible of easy regulation from the Allied point of view and it could well be fixed by an interallied committee for the apportioning of raw materials. Such a committee would watch not only over the exports from various producing countries but also over the imports into Germany. The danger of overproduction in France from her natural phosphates and from her increased output of basic slag would be small even if her production did not find a market in Germany. The agriculture of France after a long period of inaction and devastation will require an intensive fertilization similar to that of Belgium, which employs 380 kg. of super phosphate per hectare of cultivated land, as against 83 kg. per hectare employed by France before the war. The consumption of phosphatic fertilizer in France could readily be increased by a judicious propaganda launched by the producers. A reduction in the supply of phosphate to the central powers would greatly decrease the sugar beets in Germany thereby reducing appreciably her export of sugar.

RÉSUMÉ.

The various suggestions proposed are interesting possibilities for the post-war regulation of mineral distribution. In the present emergency while France is exhausted by her long struggle, practically depleted of man power, devastated in her own industries, and in those which are to be acquired in Alsace-Lorraine some such apportionment of output as that outlined above is not only advisable but absolutely essential.

We must now furnish the necessary handicap to German industry that will allow sufficient time for France to rise to the industrial prominence made possible by her own acquisitions of iron and coal. Nevertheless, in dealing with a situation that is obviously abnormal it is not well to shut our eyes to the fact that a healthy and normal condition of international industry will always be governed to a large extent by the natural laws of supply and demand. To be stable the international balance of power must be in approximate equilibrium. Forewarned by the past let us realize that in the industrial struggle which is a necessary part of the great struggle for existence no one can reach supremacy except by constant untiring effort. We must prevent Germany from becoming the dominant industrial market of the world, but the desired result should be attained not so much by choking German industry at its sources as by fostering and sustaining our own neglected industries until they reach a point where they can successfully compete with Germany in her own field. An outlaw nation in our midst will be a poor guarantee of future harmony and as MacFarlane expresses it no one wishes to create an Ireland of 70 millions instead of 4 million people in the very heart of Europe. Let us stifle the military despotism of Germany, let us safeguard the revitalized industries of France, and let us quicken the erstwhile sluggish industries of Great Britain, then let us hope for a time when the great nations of the earth may indeed represent a true partnership banded together for common welfare. Wise men say that out of great wars come, along with destruction and devastation, great advantages

to the human race. Today while we yet stand only in the faint glimmerings of the dawn, it is hard to believe that out of evil comes good. Yet if the world shall have been able to realize, not only the cruelty and barbarism to which she refused to bow, but also the faults and short-sightedness by which many nations are in some sense responsible for allowing such a gigantic catastrophe to come to pass, and if each individual nation shall come to realize that she owes both to herself and to the world to fully develop her resources and her efficiency, not selfishly in order that she may swell her own power to the extermination of industrial development in other nations, but generously so that each nation may fulfil the share of human welfare imposed upon her by Nature, then and then only the Great War may bring forth lasting good to humanity.

RELATION OF ORE DEPOSITS TO THRUST FAULTS IN THE CENTRAL WASATCH REGION, UTAH.[1]

B. S. Butler.

The presence of reverse and thrust faults in the Wasatch Range has been known for some time,[2] but it has been only recently[3] that the close relation of ore deposits to such faults has been recognized. In 1916 and 1917 considerable detailed work was done in the district by the writer,[4] F. C. Calkins and F. F. Hintze, and the close relation of some of the ore deposits to thrust faults was shown. As this relation appears to be unusual and perhaps unique it is thought worth while to bring it especially to the attention of geologists and mining engineers.

Deposits associated with thrust faults are an important type in the Big and Little Cottonwood districts, Utah, and have yielded several million dollars worth of ore.

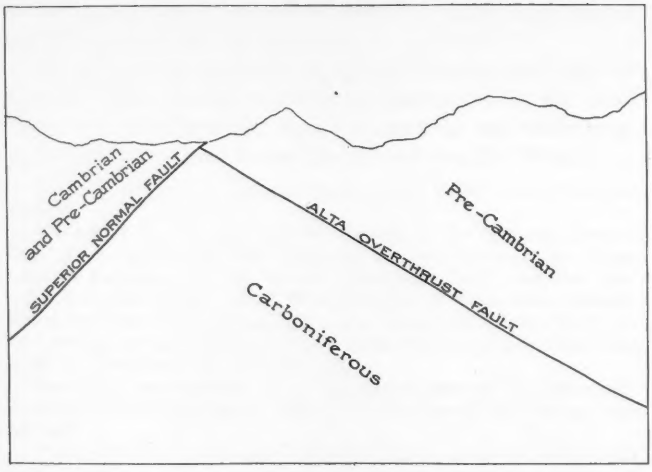
The sedimentary rocks of the region comprise pre-Cambrian quartzite, tillite and shale; Cambrian quartzite, shale and limestone; and post-Cambrian limestone, quartzite and shale ranging in age from lower Carboniferous and possibly Devonian to

[1] Published by permission of the Director of the United States Geological Survey.

[2] Boutwell, J. M., "Geology and Ore Deposits of the Park City District, Utah," U. S. Geol. Survey Prof. Paper 77, 1912; Blackwelder, Eliot, "New Light on the Geology of the Wasatch Mountains, Utah," Geol. Soc. Am. Bull., vol. 21, 1910; Loughlin, G. F., "Reconnaissance in the Southern Wasatch Mountains, Utah," *Jour. Geology*, vol. 21, pp. 436–452, 1913; Hintze, F. F., Jr., "A Contribution to the Geology of the Wasatch Mountains, Utah," *New York Acad. Sci. Annals*, vol. 23, pp. 85–143, 1913.

[3] Butler, B. S., and Loughlin, G. F., "A Reconnaissance of the Cottonwood-American Fork Mining Region, Utah," U. S. Geol. Survey Bull. 620, pp. 165–226, 1916.

[4] A map of the districts and description of the geology and ore deposits by B. S. Butler and F. C. Calkins is included in the "Ore Deposits of Utah," Prof. Paper 111, now in press.



Alta overthrust fault, north side of Little Cottonwood Canyon.

Jurassic; with a total aggregate thickness of several thousand feet.

The structure of the region is exceedingly complex. The rocks were first affected by normal faulting, then followed folding accompanied by thrust faulting, next came the intrusion of large bodies of igneous rock with accompanying reverse faulting. Finally, there was renewed normal faulting. Attention here is confined to thrust faults.

The thrust faults range in magnitude from those on which the movement was but a few feet and which have simply resulted in the apparent thickening of a formation to those on which the movement is measured in thousands of feet and which have caused rocks of pre-Cambrian age to override those of Carboniferous age. The fault planes generally cut the beds at small angles. To this approximate parallelism of fault planes and bedding can probably be attributed the failure of those geologists who have made hasty reconnaissance examinations in the region to recognize the thrust faulting and as the normal faulting also escaped their observation they were led to overestimate greatly the thickness of the sedimentary series.

A number of important ore deposits of the region occur in the breccia of the thrust faults adjacent to fissures that are younger than the thrust faulting. They form irregular shoots (Fig. 13) along the intersection of fault and fissure and are the result of replacement of the fault breccia by solutions which gained access through the fissure. The degree of the replacement appears to have been determined by two principal factors: (1) the extent and character of the brecciation, and (2) the chemical composition of the brecciated material. This material generally appears to have been derived from the rock immediately underlying it, indicating that there was no great dragging of the shattered footwall material even though the movement on the fault may have amounted to scores or hundreds or even thousands of feet.

Both the brecciation and replacement occurred most extensively in limestone. The limestone is most thoroughly brecciated where it has been overridden by hard massive quarzite, although

the amount of brecciation varies considerably in different beds of the limestone. Where shale was thrust upon limestone the brecciation of the limestone was much less. Where limestone was thrust over limestone the brecciation varies in degree, but frequently extends through a rather thick zone. Where the

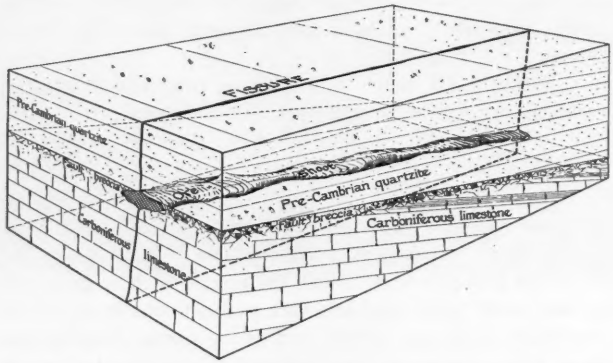


FIG. 13. Stereogram illustrating location of ore shoot at intersection of thrust fault and fissure.

faulting brought shale in contact with shale the brecciation was slight; in some places so slight that the fault plane can be located only by careful examination.

Of the many beds making up the great thickness of limestone in the region only a few, partly on account of slight differences in chemical composition, were especially susceptible to mineralization, and the large replacement beds deposits not obviously connected with faulting are confined to these few strata. The mineralization on the thrust faults is apparently also partly dependent on the chemical composition of the limestone. The breccia formed from certain beds is much more extensively and completely replaced than that formed from other beds, so that in following an ore shoot on the dip large relatively rich bodies of ore give place to smaller and relatively poor bodies, or vice versa,

as the fault zone crosses different strata. Where it passes into shale the ore may give out entirely and the fault zone show only slight mineralization.

The lowest and most extensive thrust fault of the region known as the Alta fault is compound, including in places between its main walls large lenses of Cambrian shale and limestone. Along this fault have been found the ore bodies of the Cardiff and Columbus-Rexall mines, the western deposit of the Wasatch Mines Co., and the deposit of the Cottonwood-Atlantis mine. Above this is the Columbus fault on which are some of the deposits of the Wasatch mines (formerly the Columbus Consolidated mine). Certain of the deposits of the South Hecla mine are also believed to be on a southern extension of this fault. Part Part of the deposits of the Michigan-Utah Consolidated mines are on a thrust fault that may be a faulted portion of one of those already mentioned. The ore body of the Emma mine is in a highly brecciated zone that probably represents a minor thrust fault.

DISCUSSION

This department has been established by the editors in order to afford to those interested in questions relating to economic geology an opportunity for informal discussion. Contributions are cordially invited either in the form of discussion of more formal papers appearing in earlier numbers or bearing upon matters not previously treated. Letters should be directed to the Editor, Sheffield Scientific School of Yale University, New Haven, Conn. The full name of the author should be attached to all communications.

GRAPHIC DETERMINATION OF DIP COMPONENTS WHERE DIPS ARE MEASURED IN FEET PER MILE.

Sir: I am sending herewith a series of curves, plotted on co-ordinates, which may be used to find the inclination of a stratum, or of any relatively flat surface or layer, in directions not perpendicular to strike, when dips are low and are recorded in *feet per mile*. It has proved to be of some value in determinations of convergence and in other problems arising in petroleum geology.

The use of the diagram may be illustrated as follows: Suppose that the strata dip 50 ft. per mile due north and that we want to find their inclination in the direction N. 30° E. In like manner, the true dip may be obtained from a known dip component, thus: Let the strike of the beds be N. 10° W. and suppose that two well logs show that these beds are inclined 20 feet per mile in a direction N. 40° E. The true dip is in the direction N. 80° E. The angle between the direction of the true dip and the direction of the dip component is 40°. On the diagram find the point where the vertical line marked "40°" intersects the curve marked "20 ft." This is approximately on the horizontal line marked "40 ft," indicating that the required true dip is about 40 feet per mile.

Observe that, in all cases, the horizontal lines are for true dips

and the curves are for dip components. The lattter inclination may be referred to as the dip component in this direction. The horizontal angle between the true dip and the dip component is here 30 degrees. Find the point on Fig. 14 where the vertical

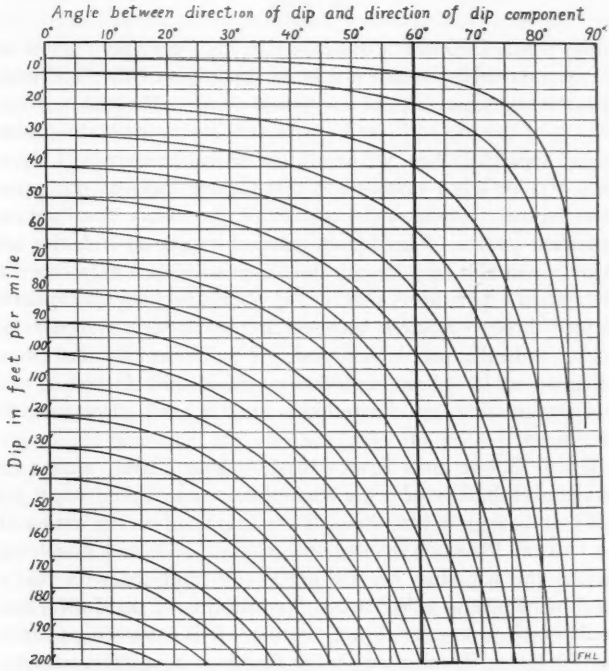

Angle between direction of dip and direction of dip component
0° 10° 20° 30° 40° 50° 60° 70° 80° 90°
Dip in feet per mile
10' 20' 30' 40' 50' 60' 70' 80' 90' 100' 110' 120' 130' 140' 150' 160' 170' 180' 190' 200'
FHL

FIG. 14.

line labeled "30°" (top of Fig.) intersects the horizontal line marked "50 ft." (left of Fig.). This point is between two curves which, if followed up to the left margin of the figure, will be seen to be marked "40 ft." and "50 ft.," respectively. Since the point in question lies about one third way from the 40-foot

to the 50-foot curve, the required dip component is found to be between 43 and 44 feet per mile in the direction N. 30° E.

FREDERIC H. LAHEE.

INTRUSIVE ORIGIN OF THE GULF COAST SALT DOMES.

Sir:—Mr. DeGolyer's discussion in the December number of this journal of my recent article on the origin of the Gulf coast salt domes presents a clear analysis of the possible modes of formation of the cap rocks and emphasizes a very interesting point which apparently has not heretofore been considered. I agree with Mr. DeGolyer's conclusion that the cap rocks do not represent residual material, and I admit that the theory that they are reworked masses of bedded anhydrite brought up with the salt is not a plausible one, though this subject will probably bear investigation. The theory that the cap rocks are chiefly precipitates formed through reaction between circulating waters appears at present to be the most logical, and it is certain at least that circulating waters have been important agents in their formation and that any reactions which are likely to have taken place must be considered.

Mr. DeGolyer cites figures to show that $CaSO_4$ attains its maximum solubility of 7.5 *g/l* in solutions containing 129.5 *g/l* NaCl, and suggests that the ordinary sulphate-bearing waters of the Coastal Plain, on coming into contact with and dissolving part of the salt plug, become practically saturated with NaCl, which would cause a decrease in the solubility of the $CaSO_4$ and would result in its partial precipitation. It is interesting to note that Professor Harris cited similar figures in connection with his theory, but that he drew the opposite inference from them—viz., that gypsum would be precipitated as the concentration of sodium chloride decreased. There is no doubt that the mutual influence on solubility which many salts exert has been a basic principle in cap rock formation, and that the relations between $CaSO_4$ and NaCl are especially important because of the predominance of these two materials. I do not believe, however, that the par-

ticular inference which Mr. DeGolyer draws from these figures will be generally applicable, for the normal Coastal Plain waters, at least to a depth of 1,500 feet, are surprisingly poor in sulphate. None of those analyzed in eastern Texas carry more than 2 *g/l* $CaSO_4$ and the average is far less than 1 *g/l*, whereas in order to precipitate $CaSO_4$ when saturated with NaCl they would have to carry more than 5 *g/l*. It is possible that the normal waters from a depth of several thousand feet are sufficiently rich in sulphate to conform to these conditions, but judgment on this point must await further evidence.

Mr. Jones' discussion in the December number of this journal brings up a very interesting and important phase of salt dome geology—the source of the oil—which I avoided considering in my paper. The enormous quantity of oil that some of the domes have produced, together with their very limited area of structural disturbance, are perhaps the best evidence for supposing that the oil has migrated up from Cretaceous or deeper sands. On the other hand, Dumble[1] and Deussen,[2] two of the foremost authorities on the salt dome fields, regard the oil as of Tertiary age and derived from the contiguous sediments, and Van der Gracht,[3] apparently accepting this view, explains the productivity of the domes on the ground that salt has a special faculty of liberating oil from the sediments. I am inclined to agree with Dumble and Deussen, at least insofar as the Humble field is concerned, though the whole question is certainly open to debate.

It might be inferred from the remarks of both Mr. DeGolyer and Mr. Jones that they credit me in some measure with formulating the tectonic theory, and if so I desire to correct this impression. The theory has long been discussed in Europe, and for several years has been familiar to Gulf coast geologists, one of whom—Dr. Dumble[4]—espoused it in a paper which appeared

[1] Dumble, E. T., Am. Inst. Min. Eng., Bull. 104, p. 1637, 1915.

[2] Deussen, Alexander, Southwestern Assoc. Petroleum Geologists Bull. 1, p. 74, 1917.

[3] Van der Gracht, W. A. I. M., *idem*, p. 91.

[4] Dumble, E. T., "Origin of the Texas Salt Domes," Am. Inst. Min. Eng., Bull. 142, p. 1629, October, 1918.

simultaneously with mine. I made no effort in my own paper to present new facts regarding the geology of the salt dome fields, but attempted simply to discuss a theory which, though well-known, has been neglected in American literature.

G. SHERBURNE ROGERS.

ROCK CLASSIFICATION FOR ENGINEERING.

Sir:—Below are some notes with reference to the classification of rocks, for the use of civil engineers, which I think will be of some interest, and I hope will start discussion along this line.

In Volume 12, page 281, of ECONOMIC GEOLOGY, John Graham Mitchell, formerly assistant professor of geology of the University of Oregon, broached this subject in a communication to the journal. The writer, during the past summer, was engaged in a similar investigation for the same railroad company in Oregon, though the locality and conditions were different. In his communication Professor Mitchell called attention to the very urgent need for a better system of classification than that now in use, and I wish to go into this matter a little more at length.

The classification of rocks given in geology handbooks is too technical and too clumsy, as now arranged, for the use of the field engineer, and we find in the literature nothing very adequate which the engineer can use. In some cases he has fallen back on a classification something like this, which all geologists will recognize as being a very loose and unsatisfactory classification. For instance, I found the following classification in use by the engineers of this railroad: (1) Solid rock, (2) sandstone, (3) cement, (4) shale, (5) earth.

Now all geologists know that there are many different kinds of solid rocks and many different kinds of sandstones and so on. No regard is paid in this classification to the differences in cementing materials in the sandstones; there is nothing in here about structure, or texture, which determine the ease or difficulty in excavating the material. No attention is paid to whether the material is weathered or to the degree of alteration. For instance the word cement may include many different kinds

of cementing substances, silica, calcium carbonate or iron oxide, and it makes a great difference which one of these is the binding substance.

A good classification will probably have to include terms generally used by geologists, but these must be so grouped that we get in any one group materials which can be excavated with about the same degree of ease or difficulty, as the case may be. In the following proposed classification very heterogeneous substances are grouped together, but taking into consideration texture, structure, and composition, we think there is included those materials which, from our experience, we judge ought to be classed together for similar rating in regard to excavation.

We realize that this classification is open to criticism, but criticism is what is invited, for an excellent way to develop a good classification is to propose one, have it criticized, and then make a new one, or if necessary several new ones.

In the case of a small job, involving little financial outlay, where not very much can be either made or lost by the contractor, the old loose classification as now used might be retained, but with a big piece of work, where thousands of cubic yards of rock have to be moved, it will pay both the company and the contractor to have a geologist. If the company retains no geologist on its staff then let it secure the temporary services of one, and have him classify the material to be excavated. In this particular case I know that several hundred dollars could have been saved.

For use in connection with this classification we think that Pirsson's "Rocks and Rock Minerals," with the tables there included for rock determination, should be used. There is no escaping the fact that the engineer must know the common rocks and minerals. If he does not know them now, he must either take a course where he can learn these, or a geologist must be retained.

The following classification has four main groups and is as follows:

Name.	
All granitic rocks, granites, diorites, etc. Sandstones (siliceous cement) Quartzites and quartz masses Traps (basalt) porphyries and volcanic glasses Conglomerates and agglomerates Gneisses, breccias	GROUP I. Solid and unweathered rocks.
All rocks of Group I. badly weathered Sandstones (lime or iron cement) Limestones and marbles Serpentines, schists, slates and argillites Hardpan (glacial, etc.)	GROUP II. Intermediate rocks.
Shales Rubble limestone Loose sandstone Coquina Marls Travertine Tuff Glacial till	GROUP III. Soft rocks.
Silt Mud Sand Gravel Volcanic ash (loose)	GROUP IV. Unconsolidated (earth).

As the advisability of placing slates in the same group with sandstones with lime or iron cement may be questioned, we would make it clear that in this case we realize the extreme hardness of some slates, but believe this feature is offset by considering their cleavage, which makes it easier to excavate them than other rocks not so hard.

It may also be pointed out that there is still considerable latitude in this classification, and there will be opportunities for dispute. For instance, one party to a contract will assert that a given rock is badly weathered, and the other will claim just the contrary. We do not see how all dispute can be avoided. It might be suggested here that in the case of large and important work a third neutral expert geologist be consulted and his decision agreed to by both parties before commencing work. Even

here changes will have to be made as the excavation proceeds and the formations newly uncovered are seen to change.

Copies of this proposed classification have been submitted to the Northwestern Association of Highway Engineers, and it is hoped that comments by these practical field men will be forthcoming. The writer would like to see this classification discussed in the pages of this journal, and hopes in the future, after he has digested these criticisms to revise it and again to submit it to interested engineering journals.

WARREN D. SMITH.

UNIVERSITY OF OREGON,
EUGENE, OREGON.

SCIENTIFIC NOTES AND NEWS[1]

W. L. UGLOW has joined the professorial staff of the Department of Geology, University of Vancouver, Vancouver, B. C.

E. S. BASTIN heads a reorganized and extended mineral resources division of the United States Geological Survey with four sections. G. F. Laughlin will be in charge of the metal section; R. W. Stone of the non-metals section; C. E. Lesher of the mineral fuel section, and J. B. Umpleby of the foreign-reserves section.

JAMES O. LEWIS, petroleum geologist, who was formerly in charge of the experiment station of the U. S. Bureau of Mines, Bartlesville, Oklahoma, has succeeded Chester Naramore as chief petroleum technologist of the U. S. Bureau of Mines, Washington, D. C.

DR. W. G. MILLER has returned from London.

PROF. R. A. DALY has returned from France to resume his work in the geological department of Harvard University.

N. L. BOWEN, formerly of the geophysical laboratory of Washington, has been appointed professor of mineralogy at Queen's University, Kingston, Ontario.

JOHN WELLINGTON FINCH has returned from China to New York.

CHARLES H. WHITE has received his discharge from the Army and has returned to the Hobart Building, San Francisco.

ALLEN H. ROGERS and SYDNEY H. BALL are examining the Ray Hercules copper mine in Arizona.

[1] Geologists, mining engineers and others interested in applied geology are invited to keep the editor informed of new investigations of mining districts or scientific studies undertaken by them, together with such other scientific and personal items as may come to their notice.

COL. JOHN C. GREENWAY will soon return to Bisbee, Ariz., to resume his duties as general manager of the Calumet & Arizona Mining Company.

HOWLAND BANCROFT, of Denver, has been in San Francisco recently.

COURTNEY DE KALB, associate editor of the M. & S. P., has returned to San Francisco.

SCOTT TURNER has received his discharge from the Navy and is in Lansing, Mich.

BASIL PRESCOTT has returned to Lordsburg, N. M., from field examination work at Santa Eulalia, Chihuahua, Mexico.

WILLIAM W. MEIN sailed from San Francisco for Nicaragua, February 11.

J. R. FINLAY is spending the winter at Tucson, Ariz.

J. M. WADSWORTH has resigned from the U. S. Bureau of Mines to enter the employ of the Empire Gas and Fuel Co., Bartlesville, Okla.

CHESTER NARAMORE, chief petroleum technologist of the U. S. Bureau of Mines, Washington, D. C., has resigned to accept private employment.

J. P. HODGSON, who has been with the Copper Queen, Bisbee, Ariz., will succeed M. H. McLean as general manager of the Detroit copper mines of the Phelps Dodge Corporation.

W. D. B. MOTTER, JR., has resigned as manager for the Benson Mines Co., to became an assistant consulting mining engineer, with Guggenheim Bros., with headquarters at 120 Broadway, N. Y.

J. P. HUTCHINS, consulting mining engineer, sailed February 17 for southern Russia, via London, the Mediterranean and Constantinople.

G. W. MILLER has opened an office as consulting engineer at Los Angeles.

W. H. BLACKBURN, of Tonopah, has been elected president of the Nevada Mine Operators' Association.

ISAKICHI TAKENOUCHI, of the Sumitomo Beshi copper mine, in Japan, is visiting the copper districts of Arizona.

FRANK H. PROBERT has been appointed a member of a U. S. Government commission to study mining and metallurgical conditions in Europe.

G. C. BATEMAN, of Cobalt, Ontario, was recently in San Francisco.

D'ARCY WEATHERBE has returned from China to London.

R. C. GEMMELL, who has been in California, has returned to Salt Lake City.

N. O. BAGGE, mining engineer, who has been in Arizona, has returned to New York.

H. B. JOHNSON, mining engineer, has returned to Boston from professional work in Texas.

J. P. GORDON, government engineer for Manitoba, has begun a reconnaissance survey of the proposed railway from the Pas to the Flin Flon copper field.

FREDERICK BURBIDGE, mining engineer, general manager of the Federal Mining and Smelting Co., of Wallace, Idaho, is in the Miami district, Okla., where the company is operating mines.

JOSEPH CLENDENIN, vice-president of the American Smelting and Refining Co., has been made Chevalier of the Legion of Honor in recognition of his services to the French government.

E. P. MATTHEWSON, E. L. DOHENY and JOHN C. HOWARD are the new directors of the American Mining Congress.

WALTER BROADBRIDGE sailed for London the last of January.

R. W. LEONARD, president of the Coniagas Mines, Ltd., of Cobalt, Ontario, Can., has been elected president of the Engineering Institute of Canada.

WALTER HAVE HARVEY WEED was recently in Butte, Mont., inspecting the property of the Crystal Copper Co.

C. W. PURRINGTON, at Vladivostok, has temporarily joined the staff of the War Trade Board.

MR. G. E. SYLVESTER has removed from Copper Cliff to Toronto, where the International Nickel Company of Canada has established its head office. Mr. Sylvester holds the position of assistant to the president of the company.

A. T. THOMSON, assistant to the president of the Phelps Dodge Corporation, Copper Queen branch, and John S. Williams, Jr., general manager for the Montezuma Copper Co., at Nacozarit, were at Bisbee recently in conference with G. H. Dowell, general manager of the Copper Queen branch.

JOHN M. NICOL has returned to San Francisco from an investigation of mining properties in Honduras.

FERGUS H. ALLEN, manager of the Mexico Mine at El Oro, and Hedley D. Crowder, manager for the Mexican Exploration Co., have been visiting the United States for a holiday.

DANIEL GUGGENHEIM has retired from the presidency of the A. S. & R., and is succeeded by Simon Guggenheim. Edgar L. Newhouse has been made chairman of the board of directors.

A. A. HASSAN, who has been examining, with the view of developing, some manganese deposits for chemical ore in Nova Scotia, has returned to New York.

ROSSITER W. RAYMOND died on December 31 at his home in Brooklyn, N. Y., at the age of seventy-eight.

C. F. KELLEY, of the Anaconda, Joseph R. Clendenin and Murray Guggenheim, of the A. S. & R., and R. L. Agassiz, of the Calumet & Hecla, sailed from New York to Europe on January 20, in order to confer with the foreign metal consumers on behalf of the Copper Export Association.

HERBERT C. HOOVER has been promoted to the grade of Commander in the Order of the Legion of Honor.

BULKELEY WELLS is president of the American Mining Congress.

HUGH F. K. PICARD, of Sulman & Picard, is president-elect of the Institution of Mining and Metallurgy, London.

THE CANADIAN MINING INSTITUTE held its twenty-first annual meeting on March 5–7, 1919.

THE AMERICAN MINING CONGRESS meeting was held in San Francisco, January 15 and 16, with about 150 in attendance. Albert Burch presided. Many papers were read pertaining to mining and its relation to economics and politics.

The following offices were filled:

Directors for one-year term: Andrew Carrigan, L. D. Gordon, M. H. Whittier, K. R. Kingsbury and Clifford G. Dennis.

Directors for two-year term: Albert Burch, George W. Metcalf, W. J. Loring, E. L. Doheney and John Barneson.

Directors for three-year term: F. W. Bradley, T. A. Rickard, J. H. Mackenzie, L. P. St. Clair and H. R. Gallagher.

Mr. Rickard has declined the honor, believing that he can be more useful as a detached critic and friend of the Congress.

ITALY, stimulated by the shortage of coal, is now using much volcanic heat. A 16,000-H.P. plant operates continuously at Larderello, where steam superheated to 165 degrees C. issues from the ground. The steam is used indirectly for heating boilers on account of the corrosive materials it contains.

THE state of Idaho has provided for the creation of a State Bureau of Mines and Geology. Coöperative work with the U. S. Bureau of Mines and the U. S. Geological Survey is planned as well as geologic and economic investigations of the mineral resources of the state.